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(54) Title: ANTI-CD20 ANTIBODIES AND FUSION PROTEINS THEREOF AND METHODS OF USE

(57) Abstract: The present invention provides humanized, chimeric and human anti-CD20 antibodies and CD 20 antibody fusion proteins that bind to a human B cell marker, referred to as CD20, which is useful for the treatment and diagnosis of B-cell disorders, such as B-cell malignancies and autoimmune diseases, and methods of treatment and diagnosis.

Anti-CD20 Antibodies and Fusion Proteins Thereof and Methods of Use

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to humanized, chimeric and human anti-CD20 antibodies, particularly monoclonal antibodies (mAbs) therapeutic and diagnostic conjugates of humanized, chimeric and human anti-CD20 antibodies and methods of treating B cell lymphomas and leukemias and various autoimmune diseases using humanized, chimeric and human anti-CD20 antibodies. The present invention relates to antibody fusion proteins or fragments thereof comprising at least two anti-CD20 mAbs or fragments thereof or at least one anti-CD20 MAb or fragment thereof and at least one second MAb or fragment thereof, other than the antiCD20 MAb or fragment thereof. The humanized, chimeric and human anti-CD20 mAbs, fragments thereof, antibody fusion proteins thereof or fragments thereof may be administered alone, as a therapeutic conjugate or in combination with a therapeutic immunoconjugate, with other naked antibodies, or with therapeutic agents or as a diagnostic conjugate. The present invention relates to DNA sequences encoding humanized, chimeric and human anti-CD20 antibodies, and antibody fusion proteins, vectors and host cells containing the DNA sequences, and methods of making the humanized, chimeric and human anti-CD20 antibodies.

2. Background

The immune system of vertebrates consists of a number of organs and cell types which have evolved to accurately recognize foreign antigens, specifically bind to, and eliminate/destroy such foreign antigens. Lymphocytes, amongst others, are critical to the immune system. Lymphocytes are divided into two major sub-populations, T cells and B cells. Although inter-dependent, T cells are largely responsible for cell-mediated immunity and B cells are largely responsible for antibody production (humoral immunity).

In humans, each B cell can produce an enormous number of antibody molecules. Such antibody production typically ceases (or substantially decreases) when a foreign antigen has been neutralized. Occasionally, however, proliferation of a particular B cell will continue unabated and may result in a cancer known as a B cell lymphoma. B-cell lymphomas, such as the B-cell subtype of non-Hodgkin's lymphoma, are significant contributors to cancer mortality. The response of B-cell malignancies to various forms of treatment is mixed. For example, in cases in which adequate clinical staging of non-Hodgkin's lymphoma is possible, field radiation therapy can provide satisfactory treatment. Still, about one-half of the patients die from the disease. Devesa *et al.*, *J. Nat'l Cancer Inst.* *79*:701 (1987).

The majority of chronic lymphocytic leukemias are of B-cell lineage. Freedman, *Hematol. Oncol. Clin. North Am.* *4*:405 (1990). This type of B-cell malignancy is the most common leukemia in the Western world. Goodman *et al.*, *Leukemia and Lymphoma* 22:1 (1996). The natural history of chronic lymphocytic leukemia falls into several phases. In the early phase, chronic lymphocytic leukemia is an indolent disease, characterized by the accumulation of small mature functionally-incompetent malignant B-cells having a lengthened life span. Eventually, the doubling time of the malignant B-cells decreases and patients become increasingly symptomatic. While treatment can provide symptomatic relief, the overall survival of the patients is only minimally affected. The late stages of chronic lymphocytic leukemia are characterized by significant anemia and/or thrombocytopenia. At this point, the median survival is less than two years. Foon *et al.*, *Annals Int. Medicine* *113*:525 (1990). Due to the very low rate of cellular proliferation, chronic lymphocytic leukemia is resistant to cytotoxic drug treatment.

Traditional methods of treating B-cell malignancies, including chemotherapy and radiotherapy, have limited utility due to toxic side effects. The use of monoclonal antibodies to direct radionuclides, toxins, or other therapeutic agents offers the possibility that such agents can be delivered selectively to tumor sites, thus limiting toxicity to normal tissues. Also, the presence of B-cell antigens on these B-cell malignancies makes them optimal targets for therapy with unconjugated B-cell antibodies, such as against CD19, CD20, CD21, CD23, and CD22 markers on B-cells. HLA-DR and other antigens may serve as targets for normal and malignant B-cells, although they are also expressed on other cell types. Further, certain MUC1, MUC2,

MUC3, and MUC4 antigens, preferably MUC1, are also expressed in different hematopoietic malignancies, including B-cell tumors expressing CD20 and other B-cell markers. Still other antigen targets, such as those associated with the vascular endothelium of tumors, including tenascin, vascular endothelium growth factor (VEGF), and placental growth factor (PlGF), as well as other categories of antigens associated with B-cell malignancies, such as oncogene products, are also suitable targets for said complementary antibodies for use in the present invention.

B cells comprise cell surface proteins which can be utilized as markers for differentiation and identification. One such human B-cell marker is the human B lymphocyte-restricted differentiation antigen Bp35, referred to as CD20. CD20 is expressed during early pre-B cell development and remains until plasma cell differentiation. CD20 is expressed on both normal B cells and malignant B cells whose abnormal growth can lead to B-cell lymphomas. Antibodies against the CD20 antigen have been investigated for the therapy of B-cell lymphomas. For example, a chimeric anti-CD20 antibody, designated as "IDEC-C2B8," has activity against B-cell lymphomas when provided as unconjugated antibodies at repeated injections of doses exceeding 500 mg per injection. Maloney *et al., Blood 84*:2457 (1994); Longo, *Curr. Opin. Oncol. 8*:353 (1996). About 50 percent of non-Hodgkin's patients, having the low-grade indolent form, treated with this regimen showed responses. Therapeutic responses have also been obtained using ^{131}I-labeled B1 anti-CD20 murine monoclonal antibody when provided as repeated doses exceeding 600 mg per injection. Kaminski *et al., N. Engl. J. Med. 329*:459 (1993); Press *et al., N. Engl. J. Med. 329*:1219 (1993); Press *et al., Lancet 346*:336 (1995). However, these antibodies, whether provided as unconjugated forms or radiolabeled forms, have not shown high rates of objective and durable responses in patients with the more prevalent and lethal form of B-cell lymphoma, the intermediate or aggressive type. Therefore, a need exists to develop an immunotherapy for B-cell malignancies that achieves a therapeutic response of significant duration.

Additional studies targeting CD20 surface antigen have been demonstrated using an anti-CD20 murine monoclonal antibody, IF5, which was administered by continuous intravenous infusion to B cell lymphoma patients. Extremely high levels (>2 grams) of 1F5 were reportedly required to deplete circulating tumor cells, and the results were described as being "transient." Press et al., "Monoclonal Antibody 1F5

(Anti-CD20) Serotherapy of Human B-Cell Lymphomas." *Blood* 69/2:584-591 (1987). However, a potential problem with this approach is that non-human monoclonal antibodies (e.g., murine monoclonal antibodies) typically lack human effector functionality, i.e., they are unable to mediate complement-dependent lysis or lyse human target cells through antibody-dependent cellular toxicity or Fc-receptor mediated phagocytosis. Furthermore, non-human monoclonal antibodies can be recognized by the human host as a foreign protein and, therefore, repeated injections of such foreign antibodies can lead to the induction of immune responses leading to harmful hypersensitivity reactions. For murine-based monoclonal antibodies, this is often referred to as a Human Anti-Mouse Antibody (HAMA) response.

The use of chimeric antibodies is more preferred because they do not elicit as strong a HAMA response as murine antibodies. Chimeric antibodies are antibodies which comprise portions from two or more different species. For example, Liu, A. Y. *et al*, "Production of a Mouse-Human Chimeric Monoclonal Antibody to CD20 with Potent Fc-Dependent Biologic Activity" *J. Immun.* 139/10:3521-3526 (1987), describe a mouse/human chimeric antibody directed against the CD20 antigen. See also, PCT Publication No. WO 88/04936. However, no information is provided as to the ability, efficacy or practicality of using such chimeric antibodies for the treatment of B cell disorders in the reference. It is noted that *in vitro* functional assays (e.g., complement-dependent lysis (CDC); antibody dependent cellular cytotoxicity (ADCC), etc.) cannot inherently predict the *in vivo* capability of a chimeric antibody to destroy or deplete target cells expressing the specific antigen. See, for example, Robinson, R. D. *et al.*, "Chimeric mouse-human anti-carcinoma antibodies that mediate different anti-tumor cell biological activities," *Hum. Antibod. Hybridomas* 2:84-93 (1991) (chimeric mouse-human antibody having undetectable ADCC activity). Therefore, the potential therapeutic efficacy of a chimeric antibody can only truly be assessed by in vivo experimentation, preferably in the species of interest for the specific therapy.

One approach that has improved the ability of murine monoclonal antibodies to be effective in the treatment of B-cell disorders has been to conjugate a radioactive label or chemotherapeutic agent to the antibody, such that the label or agent is localized at the tumor site. For example, the above-referenced 1F5 antibody and other B-cell antibodies have been labeled with ^{131}I and were reportedly evaluated for

biodistribution in two patients. See Eary, J. F. *et al.*, "Imaging and Treatment of B-Cell Lymphoma" *J. Nuc. Med.* 31/8:1257-1268 (1990); see also, Press, O. W. *et al.*, "Treatment of Refractory Non-Hodgkin's Lymphoma with Radiolabeled MB-1 (Anti-CD37) Antibody" *J. Clin. Onc.* 7/8:1027-1038 (1989) (indication that one patient treated with ^{131}I-labeled IF-5 achieved a partial response); Goldenberg, D. M. *et al.*, "Targeting, Dosimetry and Radioimmunotherapy of B-Cell Lymphomas with ^{131}I-Labeled LL2 Monoclonal Antibody" *J. Clin. Oncol.* 9/4:548-564 (1991) (three of eight patients receiving multiple injections reported to have developed a HAMA response to this CD22 murine antibody); Appelbaum, F. R. "Radiolabeled Monoclonal Antibodies in the Treatment of Non-Hodgkin's Lymphoma" *Hem./Oncol. Clinics of N. A.* 5/5:1013-1025 (1991) (review article); Press, O. W. *et al.* "Radiolabeled-Antibody Therapy of B-Cell Lymphoma with Autologous Bone Marrow Support." *New England Journal of Medicine* 329/17: 1219-12223 (1993) (^{131}I-labeled anti-CD20 antibody IF5 and B1); and Kaminski, M. G. *et al* "Radioimmunotherapy of B-Cell Lymphoma with [^{131}I] Anti-B1 (Anti-CD20) Antibody". *NEJM* 329/7:459 (1993) (^{131}I-labeled anti-CD20 antibody B1; hereinafter "Kaminski"); PCT published application WO 92/07466 (antibodies conjugated to chemotherapeutic agents such as doxorubicin or mitomycin). However, these approaches have not eliminated the obstacles associated with using murine antibodies, despite the fact that many patients with lymphoma who have received prior aggressive cytotoxic chemotherapy are immune suppressed, thus having lower HAMA rates than lymphoma patients who have not been heavily pretreated.

Autoimmune diseases are a class of diseases associated with B-cell disorders. Examples include immune-mediated thrombocytopenias, such as acute idiopathic thrombocytopenic purpura and chronic idiopathic thrombocytopenic purpura, myasthenia gravis, lupus nephritis, lupus erythematosus, and rheumatoid arthritis. The most common treatments are corticosteroids and cytotoxic drugs, which can be very toxic. These drugs also suppress the entire immune system, can result in serious infection, and have adverse affects on the bone marrow, liver and kidneys. Other therapeutics that have been used to treat Class III autoimmune diseases to date have been directed against T-cells and macrophages. There is a need for more effective methods of treating autoimmune diseases, particularly Class III autoimmune diseases.

To address the many issues related to B-cell disorders and their treatment, the present invention provides humanized, chimeric and human anti-CD20 monoclonal antibodies with the same complementarity determining regions (CDRs) that bind to the CD20 antigen of the present invention used alone, conjugated to a therapeutic agent or in combination with other treatment modalities, for the treatment of B cell lymphomas and leukemias and autoimmune disorders in humans and other mammals without the adverse responses associated with using murine antibodies.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides humanized, chimeric and human anti-CD20 antibodies that bind to a human B cell marker, referred to as CD20, which is useful for the treatment and diagnosis of B-cell disorders, such as B-cell malignancies and autoimmune diseases.

The present invention further provides methods of treatment of mammalian subjects, such as humans or domestic animals, with one or more humanized, chimeric and human CD20 antibodies, alone, as an antibody fusion protein, as a therapeutic conjugate alone or as part of an antibody fusion protein, in combination, or as a multimodal therapy, with other antibodies, other therapeutic agents or immunomodulators or as an immunoconjugate linked to at least one therapeutic agent, therapeutic radionuclide or immunomodulator. These humanized, chimeric and human CD20 antibodies can also be used as a diagnostic imaging agent alone, in combination with other diagnostic imaging agents, and/or in conjunction with therapeutic applications.

The present invention additionally is directed to anti-CD20 mAbs or fragments thereof that contain specific murine CDRs or a combination of murine CDRs from more than one murine or chimeric anti-CD20 MAb that have specificity for CD20. These mAbs can be humanized, chimeric or human anti-CD20 mAbs.

The present invention is also directed to antibody fusion proteins comprising at least two anti-CD20mAbs or fragments thereof or a first MAb comprising an anti-CD20mAbs or fragments thereof and a second MAb.

The present invention is further directed to a therapeutic or diagnostic conjugates of the anti-CD20 mAbs or fragments thereof or antibody fusion proteins of the anti-CD20 mAbs or other mAbs or fragments thereof bound to at least one

therapeutic agent or at least one diagnostic agent. Antibody fusion proteins with multiple therapeutic agents of the same or different type are encompassed by the present invention.

The present invention is additionally directed to a method of using the anti-CD20 mAbs or fragments thereof or antibody fusion proteins thereof or fragments thereof for therapy, either alone, in combination with each other, as the antibody component of a therapeutic immunoconjugate with one or more therapeutic agents or each administered in combination with one or more therapeutic agents or with an immunoconjugate with one or more therapeutic agents.

The present invention further is directed to a method of using the anti-CD20 mAbs or fragments thereof or antibody fusion proteins thereof or fragments thereof as a diagnostic bound to one or more diagnostic agents.

The present invention additionally is directed to a method of pretargeting a cell in a patients suffering from a B-cell lymphoma or leukemia or an autoimmune disease using an antibody fusion protein or fragment thereof of the present invention.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 discloses the V gene sequences cloned by RT-PCR from a hybridoma cell line producing a murine anti-CD20, and the deduced amino acid sequences of the variable light (Figure 1A) and heavy chain (Figure 1B) of the A20 antibody, designated as A20Vk and A20VH, respectively. Underlined arrows indicate the sequences of the PCR primers used for cloning. The putative CDR region sequences, as defined by the Kabat numbering scheme, are shown in bold and underlined. Amino acid sequences are given as single-letter codes below the corresponding nucleotide sequence. The Kabat numbering scheme was used for amino acid residues. Amino acid residues numbered by a letter represent the insertion residue according to Kabat, and have the same number as that of the previous residue. For example, residues 82, 82A, 82B and 82C in Figure 1B are indicated as 82 A, B, and C, respectively..

Figure 2 discloses the Vk, the variable light chain, and the VH, the variable heavy chain, sequences of cA20, a chimeric anti-CD20 antibody. The CDR region sequences are shown in bold and underlined. The amino acid residues and the nucleotides are numbered sequentially and same numbering system is used for

humanized V sequences. The light chain variable region is shown in Fig. 2A and the heavy chain variable region is shown in Fig. 2B. The numbering system is the same as for Figure 1. The restriction sites used for constructing cA20 are underlined.

Figure 3 shows a comparison of the binding affinities of the chimeric A20 (cA20), and murine A20, (A20), in a cell surface competitive binding assay against ^{125}I-labled A20. Increasing concentrations of cA20 blocked the binding of radiolabeled A20 to Raji cells (as depicted by closed circles) in a comparable manner as that of murine A20 (depicted by closed diamonds).

Figure 4 compares the amino acid sequences of the variable heavy chain (VH) and variable light chain (Vk) of human antibodies, and chimeric and humanzied anti-CD20 antibodies. Figure 4A compares the amino acid sequences of the variable heavy chain (VH) of the human antibodies, EU and NEWM (FR4 only), the chimeric antibody, (cA20VH) and two humanized antibodies, (hA20VH1 and hA20VH2) and Figure 4B compares the amino acid sequences of the variable light chain (Vk) of the human antibody, (REIVk), a chimeric antibody, (cA20Vk), and a humanized antibody, (hA20Vk). Dots indicate that the residues in A20 are identical to the corresponding residue in the human antibody. The CDRs are identified as a boxed region. The Kabat numbering scheme was used to number the amino acid residues.

Figure 5 discloses the nucleotide sequences of hA20 light chain V genes, (hA20Vk) (Figure 5A), and heavy chain V genes, hA20VH1 (Figure 5B) and hA20VH2 (Figure 5C), as well as the adjacent flanking sequences of the VKpBR2 (Figure 5A) and VHpBS2 (Figures 5B and 5C) staging vectors, respectively. The non-translated nucleotide sequences are shown in lowercase. The restriction sites used for subcloning are underlined and indicated. The secretion signal peptide sequence is indicated by a double underline. Numbering of Vk and VH amino acid residues is same as that in Figure 2.

Figure 6 shows the results of a cell surface competitive binding assay to compare the binding activity of two humanized A20 antibodies, (hA20-1 and hA20-2), with that of A20, cA20 and a chimeric anti-CD20 MAb, c2B8. Figure 6A shows hA20-1 (closed triangles) and hA20-2 (closed circles) and the murine anti-CD20 antibody, A20 (closed squares) competed equally well for the binding of ^{125}I-A20 to Raji cells. Figure 6B shows hA20-1 (closed circles), cA20 (closed squares) and c2B8 (closed diamonds) competed equally well for the binding of ^{125}I-c2B8 to Raji cells.

Figure 7 discloses the constant region of a human IgG1 (CH-hinge) (Figure 7A) and the constant region of a human kappa chain (Ck) (Figure 7B).

Figure 8 is a competitive cell surface binding assay. Ag-binding specificity and affinity studies of humanized anti-CD20 Abs (cA20, hA20, and c1F5, purified by affinity chromatography on a Protein A column) were evaluated by a cell surface competitive binding assay with murine 2B8 and rituximab (IDEC Pharmaceuticals Corp., San Diego, CA). Figure 8 (A) is a comparison of the binding activities of cA20 (square), hA20-1 (triangle) and hA20-1 (circle) with that of m2B8 (diamond); figure 8 (B) compares of the binding activities of cA20 (square), c1F5 (triangle) and rituximab (diamond).

Figure 9 is a study comparing the binding activities of hA20 with other anti-CD20 Abs, including rituximab and murine B1, by a cell surface competitive binding assay. A constant amount (100,000 cpm, ~10 ìCi/ìg) of ^{125}I-labeled rituximab was incubated with Raji cells in the presence of varying concentrations (0.2-700 nM) of competing Abs, hA20 (triangle), mB1 (Downward triangle) or rituximab (square) at 4°C for 1-2 h.

Figure 10 depicts the cytotoxic effect of crosslinked hA20 and other CD20 Abs on cultured lymphoma cells. Total cell and viable cell cell populations were measured by (A) trypan blue staining and cell counting or (B) MTT assay.

Figure 11 is a graph of *in vivo* therapy studies with various anti-CD20 and other Abs. Raji cells administered i.v. to SCID mice, to create a Raji lymphoma model of disseminated disease.

Figure 12 is a graph depicting *in vivo* therapy with hA20 and hLL2. Raji cells administered i.v. to SCID mice, to create a Raji lymphoma model of disseminated disease.

DETAILED DESCRIPTION OF THE INVENTION

1. Overview

As discussed above, anti-CD20 antibodies that are unconjugated or labeled with a therapeutic radionuclide, have failed to provide high rates of objective and lasting responses in patients with intermediate or aggressive forms of B-cell lymphoma. The present invention provides a humanized, a chimeric and a human anti-CD20 antibody and antibody fusion proteins thereof useful for treatment of

mammalian subjects, humans and domestic animals, alone, as a conjugate or administered in combination with other therapeutic agents, including other naked antibodies and antibody therapeutic conjugates.

The anti-CD20 mAbs of the present invention contain specific murine CDRs or a combination of murine CDRs from more than one murine or chimeric anti-CD20 MAb that have specificity for the CD20 antigen. The anti-CD20 mAbs of the present invention are humanized, chimeric or human mAbs and they contain the amino acids of the CDRs of a murine anti-CD20 MAb and retain substantially the B-cell and B-cell lymphoma and leukemia cell targeting of the murine anti-CD20 MAb. The CDRs of the light chain variable region of the anti-CD20 MAb comprises CDR1 comprising amino acids RASSSVSYIH, RASSSLSFMH or RASSSVSYMH; CDR2 comprising amino acids ATSNLAS; and CDR3 comprising amino acids QQWTSNPPT, HQWSSNPLT or QQSFSNPPT; and the CDRs of the heavy chain variable region of the anti-CD20 MAb comprises CDR1 comprising amino acids SYNMH; CDR2 comprising amino acids AIYPGNGDTSYNQKFKG and CDR3 comprising amino acids STYYGGDWYFDV, STYYGGDWYFNV, SHYGSNYVDYFDV or VVYYSNSYWYFDV.

In one embodiment, the humanized and chimeric MAb or fragment thereof does not contain the CDR3 of the heavy chain variable region comprising STYYGGDWYFNV. More preferably, CDR1 of the light chain variable region does not comprise RASSSLSFMH when the CDR3 of the light chain variable region comprises HQWSSNPLT and the CDR3 of the heavy chain variable region comprises SHYGSNYVDYFDV. In another embodiment, the CDR3 of the light chain variable region does not comprise HQWSSNPLT when CDR1 of the light chain variable region comprises RASSSLSFMH and when CDR3 of the heavy chain variable region comprises SHYGSNYVDYFDV. In a further embodiment, the CDR3 of the heavy chain variable region does not comprise SHYGSNYVDYFDV when the CDR1 of the light chain variable region comprises RASSSLSFMH and the CDR3 of the light chain variable region comprises HQWSSNPLT. In another embodiment, the CDR1 of the light chain variable region does not comprise RASSSVSYMH when the CDR3 of the light chain variable region comprises QQSFSNPPT and the CDR3 of the heavy chain variable region comprises VVYYSNSYWYFDV.

Further, in another embodiment, the anti-CD20 monoclonal antibody (MAb) or fragment thereof does not contain CDR3 of the light chain variable region of amino

acids QQSFSNPPT when CDR1 of the light chain variable region comprises RASSSVSYMH and the CDR3 of the heavy chain variable region comprises VVYYSNSYWYFDV. Additionally, the anti-CD20 MAb does not contain CDR3 of the heavy chain variable region with amino acids VVYYSNSYWYFDV when the CDR1 of the light chain variable region comprises RASSSVSYMH and the CDR3 of the light chain variable region comprises QQSFSNPPT.

In a preferred embodiment, the humanized anti-CD20 (hCD20) monoclonal antibody or antigen-binding fragment thereof comprising the complementarity determining regions (CDRs) of at least one murine anti-CD20 MAb variable region and the framework regions (FRs) of at least one human MAb variable region, wherein said humanized anti-CD20 MAb or fragment thereof retains substantially the B-cell and B-cell lymphoma and leukemia cell targeting of said murine anti-CD20 MAb. The humanized antibody's variable region may comprise a light chain variable region, a heavy chain variable region or a both light and heavy chain variable regions. The humanized antibody or fragment thereof may further comprise light and heavy chain constant regions of at least one human antibody.

The humanized anti-CD20 MAb or fragment thereof of the present invention comprises the CDRs of a murine anti-CD20 MAb and the framework (FR) regions of the light and heavy chain variable regions of a human antibody, while retaining substantially the B-cell, and B-cell lymphoma and leukemia cell targeting of the parent murine anti-CD20 MAb, and wherein the CDRs of the light chain variable region of the murine anti-CD20 MAb comprises CDR1 comprising amino acids RASSSVSYIH, CDR2 comprising amino acids ATSNLAS and CDR3 comprising QQWTSNPPT and the CDRs of the heavy chain variable region of murine anti-CD20 MAb comprises CDR1 comprising amino acids SYNMH, CDR2 comprising amino acids AIYPGNGDTSYNQKFKG and CDR3 comprising amino acids STYYGGDWYFDV. But the humanized anti-CD20 MAb or fragment thereof may further contain in the FRs of the light and heavy chain variable regions of the antibody at least one amino acid from the corresponding FRs of the murine MAb. The humanized MAbs may further contain the light and heavy chain constant regions of a human antibody. Specifically, the humanized anti-CD20 MAb or fragment thereof contains at least one amino acid residue 1, 5, 27, 30, 38, 48, 67, 68, 70, 95, 115 and 116 of the murine heavy chain variable region of Fig. 4A, designated as hA20VH1 or hA20VH2 and of at least one amino acid

residue 4, 21, 35, 38, 45, 46, 59, 99, 104 and 106 of the murine light chain variable region Fig. 4B, designated hA20Vk. One or more of the murine amino acid sequences can be maintained in the human FR regions of the light and heavy variable chains if necessary to maintain proper binding or to enhance binding to the CD20 antigen. More preferably the humanized anti-CD20 MAb or fragment thereof of the present invention comprises the hA20Vk of Figure 4B and the hA2VH1 of Figure 4A. Most preferably, the humanized anti-CD20 MAb or fragment thereof of the present invention comprises the hA20Vk of Figure 4B and the hA2VH2 of Figure 4A. This latter sequence contains more human amino acid sequences in the FRs of the VH2 chain than the VH1, and thus is more humanized.

The preferred chimeric anti-CD20 (cCD20) MAb or fragment thereof of the present invention comprises the CDRs of a murine anti-CD20 MAb and the FR regions of the light and heavy chain variable regions of the murine anti-CD 20 MAb, i.e., the Fvs of the parental murine MAb, and the light and heavy chain constant regions of a human antibody, wherein the chimeric anti-CD20 MAb or fragment thereof retains substantially the B-cell, and B-cell lymphoma and leukemia cell targeting of the murine anti-CD20 MAb, wherein the CDRs of the light chain variable region of the chimeric anti-CD20 MAb comprise CDR1 comprising amino acids RASSSVSYIH, RASSSLSFMH or RASSSVSYMH; CDR2 comprising amino acids ATSNLAS; and CDR3 comprising amino acids QQWTSNPPT, HQWSSNPLT or QQSFSNPPT; and the CDRs of the heavy chain variable region of the chimeric anti-CD20 MAb comprise CDR1 comprising amino acids SYNMH; CDR2 comprising amino acids AIYPGNGDTSYNQKFKG and CDR3 comprising STYYGGDWYFDV, STYYGGDWYFNV, SHYGSNYVDYFDV or VVYYSNSYWYFDV with the following provisos,

(a) wherein the CDR3 of the heavy chain variable region does not comprise STYYGGDWYFNV, when the CDR1 of the light chain variable region comprises amino acids RASSSVSYIH, CDR2 of the light chain variable region comprises amino acids ATSNLAS, CDR3 of the light chain variable region comprises amino acids QQWTSNPPT, CDR1 of the heavy chain variable region comprises amino acids SYNMH, and CDR2 of the light chain variable region comprises amino acids AIYPGNGDTSYNQKFKG;

(b) wherein the CDR3 of the heavy chain variable region does not comprise SHYGSNYVDYFDV, when the CDR1 of the light chain variable region comprises amino acids RASSSLSFMH, CDR2 of the light chain variable region comprises amino acids ATSNLAS, CDR3 of the light chain variable region comprises amino acids HQWSSNPLT, CDR1 of the heavy chain variable region comprises amino acids SYNMH, and CDR2 of the light chain variable region comprises amino acids AIYPGNGDTSYNQKFKG; and

(c) wherein the CDR3 of the heavy chain variable region does not comprise VVYYSNSYWYFDV, when the CDR1 of the light chain variable region comprises amino acids RASSSVSYMH, CDR2 of the light chain variable region comprises amino acids ATSNLAS, CDR3 of the light chain variable region comprises amino acids QQSFSNPPT, CDR1 of the heavy chain variable region comprises amino acids SYNMH, and CDR2 of the light chain variable region comprises amino acids AIYPGNGDTSYNQKFKG.

More preferably the chimeric anti-CD20 MAb or fragment thereof comprising the complementarity-determining regions (CDRs) of a murine anti-CD20 MAb and the framework (FR) regions of the light and heavy chain variable regions of the murine anti-CD20 MAb and the light and heavy chain constant regions of a human antibody, wherein the chimeric anti-CD20 MAb or fragment thereof retains substantially the B-cell, and B-cell lymphoma and leukemia cell targeting of the murine anti-CD20 MAb, wherein the CDRs of the light chain variable region of the chimeric anti-CD20 MAb comprises the CDRs shown in Figs. 4B and 4A, respectively, designated cA20Vk and cA20VH. Most preferably, the chimeric anti-CD20 MAb or fragment thereof comprises the light and heavy chain variable regions of murine anti-CD20 MAb shown in Figs. 4B and 4A, respectively, designated cA20Vk and cA20 VH.

The present invention also encompasses a human anti-CD20 MAb or fragment thereof comprising the light and heavy chain variable and constant regions of a human antibody, wherein said human CD20 MAb retains substantially the B-cell, and B-cell lymphoma and leukemia cell targeting and cell binding characteristics of a murine anti-CD20 MAb, wherein the CDRs of the light chain variable region of the human anti-CD20 MAb comprises the same CDRs as set forth above for the chimeric and humanized anti-CD20 mAbs and as shown in Figs. 4A and 4B.

The present invention is also intended to encompass antibody fusion proteins or fragments thereof comprising at least two anti-CD20 mAbs or fragments thereof, as described above. The antibody fusion protein or fragment thereof of the present invention is also intended to encompass an antibody fusion protein or fragment thereof comprising at least one first anti-CD20 MAb or fragment thereof as described above and at least one second MAb or fragment thereof, other than the antiCD20 MAb or fragment described above. More preferably this second MAb is a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, MUC2, MUC3, MUC4, Ia, HM1.24, HLA-DR, tenascin, VEGF, PIGF, an oncogene, oncogene product, or a combination thereof, and even an anti-CD20 MAb that is different than the anti-CD20 MAb described herein. The antibody fusion proteins of the present invention may be composed of one CD20 MAb and one or more of the second mAbs to provide specificity to different antigens, and are described in more detail below.

The humanized, chimeric and human anti-CD20 antibody may possess enhanced affinity binding with the epitope, as well as antitumor and anti-B-cell activity, as a result of CDR mutation and manipulation of the CDR and other sequences in the variable region to obtain a superior therapeutic agent for the treatment of B-cell disorders, including B-cell lymphomas and leukemias and autoimmune diseases. Modification to the binding specificity, affinity or avidity of an antibody is known and described in WO 98/44001, as affinity maturation, and this application summarizes methods of modification and is incorporated in its entirety by reference.

It may also be desirable to modify the antibodies of the present invention to improve effector function, e.g., so as to enhance antigen-dependent cell-mediated cytotoxicity (ADCC) and/or complement dependent cytotoxicity (CDC) of the antagonist. One or more amino acid substitutions or the introduction of cysteine in the Fc region may be made, thereby improving internalization capability and/or increased complement-mediated cell killing and ADCC. See Caron *et al., J. Ex. Med.* 176:1191-1195 (1991) and Shopes, *B.J. Immunol.* 148:2918-2022 (1992), incorporated herein by reference in their entirety. An antibody fusion protein may be prepared that has dual Fc regions with both enhanced complement lysis and ADCC capabilities.

The present invention is also directed to DNA sequences comprising a nucleic acid encoding a MAb or fragment thereof selected from the group consisting

(a) an anti-CD20 MAb or fragment thereof as described herein,

(b) an antibody fusion protein or fragment thereof comprising at least two of the anti-CD20 mAbs or fragments thereof,

(c) an antibody fusion protein or fragment thereof comprising at least one first MAb or fragment thereof comprising the anti-CD20 MAb or fragment thereof as described herein and at least one second MAb or fragment thereof, other than the antiCD20 MAb or fragment thereof, and

(d) an antibody fusion protein or fragment thereof comprising at least one first MAb or fragment thereof comprising the anti-CD20 MAb or fragment thereof and at least one second MAb or fragment thereof, wherein the second MAb is a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, MUC2, MUC3, MUC4, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an oncogene, oncogene product, or a combination thereof.

Also encompassed by the present invention are expression vectors comprising the DNA sequences. These vectors contain the light and heavy chain constant regions and the hinge region of the human immunoglobulin, in the case of vectors for use in preparing the humanized, chimeric and human anti-CD20 mAbs or antibody fusion proteins thereof or fragments thereof. These vectors additionally contain, where required, promoters that express the mAbs in the selected host cell, immunoglobulin enhances and signal or leader sequences. Vectors that are particularly useful in the present invention are pdHL2 or GS, particularly when used to express a chimeric, humanized or human antibodies, such as gigs, where the vector codes for the heavy and light chain constant regions and hinge region of IgG1. More preferably, the light and heavy chain constant regions and hinge region are from a human EU myeloma immunoglobulin, where optionally at least one of the amino acid in the allotype positions is changed to that found in a different IgG1 allotype, and wherein optionally amino acid 253 of the heavy chain of EU based on the EU number system may be replaced with alanine. See Edelman *et al.*, *Proc. Natl. Acad. Sci USA* 63: 78-85 (1969), incorporated herein in its entirety by reference.

Host cells containing the DNA sequences encoding the anti-CD20 mAbs or fragments thereof or antibody fusion proteins or fragments thereof of the present invention or host cells containing the vectors that contain these DNA sequences are encompassed by the present invention. Particularly useful host cells are mammalian cells, more specifically lymphocytic cells, such as myeloma cells, discussed in more detail below.

Also encompassed by the present invention is the method of expressing the anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof comprising: (a) transfecting a mammalian cell with a DNA sequence of encoding the anti-CD20 mAbs or fragments thereof or antibody fusion proteins or fragments thereof, and (b) culturing the cell transfected with the DNA sequence that secretes the anti-CD20 or fragment thereof or antibody fusion protein or fragment thereof. Known techniques may be used that include a selection marker on the vector so that host cells that express the mAbs and the marker can be easily selected.

The present invention particularly encompasses B-lymphoma cell and leukemia cell targeting diagnostic or therapeutic conjugates comprising an antibody component comprising an anti-CD20 MAb or fragment thereof or an antibody fusion protein or fragment thereof of the present invention that binds to the B-lymphoma or leukemia cell, that is bound to at least one diagnostic or at least one therapeutic agent.

The diagnostic conjugate comprises the antibody component comprising an anti-CD20 MAb or fragment thereof or an antibody fusion protein or fragment thereof, wherein the diagnostic agent comprises at least one photoactive diagnostic agent, and more preferably wherein the label is a radioactive label with an energy between 60 and 4,000 keV or a non-radioactive label. The radioactive label is preferably a gamma-, beta-, and positron-emitting isotope and is selected from the group consisting of ^{125}I, ^{131}I, ^{123}I, ^{124}I, ^{86}Y, ^{186}Re, ^{188}Re, ^{62}Cu, ^{64}Cu, ^{111}In, ^{67}Ga, ^{68}Ga, ^{99m}Tc, ^{94m}Tc, ^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{76}Br and combinations thereof.

The diagnostic conjugate of the present invention also utilizes a diagnostic agent, such as a contrast agent, for example, such as manganese, iron or gadolinium.

The therapeutic conjugate of the present invention comprises an antibody component comprising an antibody fusion protein or fragment thereof, wherein each of said mAbs or fragments thereof are bound to at least one therapeutic agent. The therapeutic conjugate of preferably is selected from the group consisting of a radioactive

label, an immunomodulator, a hormone, a photoactive therapeutic agent, a cytotoxic agent, which may be a drug or a toxin, and a combination thereof. The drugs useful in the present invention are those drugs that possess the pharmaceutical property selected from the group consisting of antimitotic, antikinase, alkylating, antimetabolite, antibiotic, alkaloid, antiangiogenic, apoptotic agents and combinations thereof. More specifically, these drugs are selected from the group consisting of nitrogen mustards, ethylenimine derivatives, alkyl sulfonates, nitrosoureas, triazenes, folic acid analogs, COX-2 inhibitors, pyrimidine analogs, purine analogs, antibiotics, enzymes, epipodophyllotoxins, platinum coordination complexes, vinca alkaloids, substituted ureas, methyl hydrazine derivatives, adrenocortical suppressants, antagonists, endostatin, taxols, camptothecins, anthracyclines, taxanes, and their analogs, and a combination thereof. The toxins encompassed by the present invention are selected from the group consisting of ricin, abrin, alpha toxin, saporin, ribonuclease (RNase), e.g., onconase, DNase I, *Staphylococcal* enterotoxin-A, pokeweed antiviral protein, gelonin, diphtherin toxin, *Pseudomonas* exotoxin, and *Pseudomonas* endotoxin.

Useful therapeutic conjugates of the present invention are immunomodulators selected from the group consisting of a cytokine, a stem cell growth factor, a lymphotoxin, a hematopoietic factor, a colony stimulating factor (CSF), an interferon (IFN), erythropoietin, thrombopoietin and a combination thereof. Specifically useful are lymphotoxins such as tumor necrosis factor (TNF), hematopoietic factors, such as interleukin (IL), colony stimulating factor, such as granulocyte-colony stimulating factor (G-CSF) or granulocyte macrophage-colony stimulating factor (GM-CSF)), interferon, such as interferons-α, -β or -γ, and stem cell growth factor, such as designated "S1 factor". More specifically, immunomodulator, such as IL-1, IL-2, IL-3, IL-6, IL-10, IL-12, IL-18, IL-21 interferon-γ, TNF-α or a combination thereof are useful in the present invention.

Particularly useful therapeutic conjugates comprise one or more radioactive labels that have an energy between 60 and 700 keV. Such radioactive labels are selected from the group consisting of ^{225}Ac, ^{67}Ga, ^{90}Y, , ^{111}In, ^{131}I, ^{125}I, ^{186}Re, ^{188}Re, ^{177}Lu, ^{32}P, , ^{64}Cu, ^{67}Cu, ^{212}Bi, ^{213}Bi, ^{211}At and combinations thereof Other useful therapeutic conjugates are photoactive therapeutic agent, such as a chromogen or dye.

Other useful therapeutic conjugates comprise oligonucleotides, especially antisense oligonucleotides that preferably are directed against oncogenes and oncogene products of B-cell malignancies, such as bcl-2.

The present invention particularly encompasses methods of treating a B-cell lymphoma or leukemia cell disease or an autoimmune disease in a subject, such as a mammal, including humans, domestic or companion pets, such as dogs and cats, comprising administering to the subject a therapeutically effective amount of an anti-CD20 MAb or a fragment thereof of the present invention, formulated in a pharmaceutically acceptable vehicle. This therapy utilizes a "naked antibody" that does not have a therapeutic agent bound to it. The administration of the "naked anti-CD20 antibody" can be supplemented by administering to the subject concurrently or sequentially a therapeutically effective amount of another "naked antibody" that binds to or is reactive with another antigen on the surface of the target cell or that has other functions, such as effector functions in the Fc portion of the MAb, that is therapeutic and which is discussed herein. Preferred additional mAbs are at least one humanized, chimeric, human or murine (in the case of non-human animals) MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, and HLA-DR, tenascin, VEGF, PlGF, an oncogene, oncogene product, or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

Both the naked anti-CD20 therapy alone or in combination with other naked mAbs as discussed above can be further supplemented with the administration, either concurrently or sequentially, of a therapeutically effective amount of at least one therapeutic agent, formulated in a pharmaceutically acceptable vehicle. As discussed herein the therapeutic agent may comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, an enzyme, an oligonucleotide, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

In another therapeutic method, both the naked anti-CD20 therapy alone or in combination with other naked mAbs, as discussed above, can be further supplemented with the administration, either concurrently or sequentially, of a therapeutically effective amount of at least one therapeutic conjugate, described herein and formulated in a pharmaceutically acceptable vehicle. The antibody component of the therapeutic

conjugate comprises at least one humanized, chimeric, human or murine (for non-human subjects) MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, MUC2, MUC3, MUC4, Ia, HM1.24, and HLA-DR, tenascin, VEGF, PlGF, an oncogene, oncogene product, or a combination thereof, formulated in a pharmaceutically acceptable vehicle. As discussed herein the therapeutic agent may comprise a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

As described herein the present invention particularly encompasses a method of treating a B-cell lymphoma or leukemia or an autoimmune disease in a subject comprising administering to a subject a therapeutically effective amount of an antibody fusion protein or fragment thereof comprising at least two anti-CD20 mAbs or fragments thereof of the present invention or comprising at least one anti-CD20 MAb or fragment thereof of the present invention and at least one additional MAb, preferably selected from the group consisting of mAbs reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, MUC2, MUC3, MUC4, Ia, HM1.24, and HLA-DR, tenascin, VEGF, PlGF, an oncogene, oncogene product, or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

This therapeutic method can further be supplemented with the administration to the subject concurrently or sequentially of a therapeutically effective amount of at least one therapeutic agent, formulated in a pharmaceutically acceptable vehicle, wherein the therapeutic agent is preferably a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

Further, the antibody fusion proteins can be administered to a subject concurrently or sequentially a therapeutically effective amount of a therapeutic conjugate comprising at least one MAb bound to at least one therapeutic agent, wherein said MAb component of the conjugate preferably comprises at least one humanized, chimeric, human or murine (for non-human subjects) MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22,

CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, MUC2, MUC3, MUC4, Ia, HM1.24, and HLA-DR, tenascin, VEGF, PlGF, an oncogene, oncogene product, or a combination thereof, formulated in a pharmaceutically acceptable vehicle. The antibody fusion protein itself can be conjugated to a therapeutic agent and thus provides a vehicle to attach more than one therapeutic agent to an antibody component and these therapeutic agents can be a combination of different recited agents or combinations of the same agents, such as two different therapeutic radioactive labels. Also encompassed by the present invention is a method of diagnosing a B-cell lymphoma or leukemia in a subject comprising administering to the subject, such as a mammal, including humans and domestic and companion pets, such as dogs, cats, rabbits, guinea pigs, a diagnostic conjugate comprising an anti-CD20 MAb or fragment thereof or an antibody fusion protein or fragment thereof of the present invention that binds to the lymphoma or leukemia cell, wherein the anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof is bound to at least one diagnostic agent, formulated in a pharmaceutically acceptable vehicle. The useful diagnostic agents are described herein.

2. Definitions

In the description that follows, a number of terms are used and the following definitions are provided to facilitate understanding of the present invention.

An <u>antibody</u>, as described herein, refers to a full-length (i.e., naturally occurring or formed by normal immunoglobulin gene fragment recombinatorial processes) immunoglobulin molecule (*e.g.*, an IgG antibody) or an immunologically active (i.e., specifically binding) portion of an immunoglobulin molecule, like an antibody fragment.

An <u>antibody fragment</u> is a portion of an antibody such as $F(ab')_2$, $F(ab)_2$, Fab', Fab, Fv, scFv and the like. Regardless of structure, an antibody fragment binds with the same antigen that is recognized by the intact antibody. For example, an anti-CD20 monoclonal antibody fragment binds with an epitope of CD20. The term "antibody fragment" also includes any synthetic or genetically engineered protein that acts like an antibody by binding to a specific antigen to form a complex. For example, antibody fragments include isolated fragments consisting of the variable regions, such as the "Fv" fragments consisting of the variable regions of the heavy and light chains, recombinant single chain polypeptide molecules in which light and

heavy variable regions are connected by a peptide linker ("scFv proteins"), and minimal recognition units consisting of the amino acid residues that mimic the hypervariable region.

A naked antibody is generally an entire antibody which is not conjugated to a therapeutic agent. This is so because the Fc portion of the antibody molecule provides effector functions, such as complement fixation and ADCC (antibody dependent cell cytotoxicity), which set mechanisms into action that may result in cell lysis. However, it is possible that the Fc portion is not required for therapeutic function , with other mechanisms, such as apoptosis, coming into play. Naked antibodies include both polyclonal and monoclonal antibodies, as well as certain recombinant antibodies, such as chimeric, humanized or human antibodies.

A chimeric antibody is a recombinant protein that contains the variable domains including the complementarity determining regions (CDRs) of an antibody derived from one species, preferably a rodent antibody, while the constant domains of the antibody molecule is derived from those of a human antibody. For veterinary applications, the constant domains of the chimeric antibody may be derived from that of other species, such as a cat or dog.

A humanized antibody is a recombinant protein in which the CDRs from an antibody from one species; e.g., a rodent antibody, is transferred from the heavy and light variable chains of the rodent antibody into human heavy and light variable domains. The constant domains of the antibody molecule is derived from those of a human antibody.

A human antibody is an antibody obtained from transgenic mice that have been "engineered" to produce specific human antibodies in response to antigenic challenge. In this technique, elements of the human heavy and light chain locus are introduced into strains of mice derived from embryonic stem cell lines that contain targeted disruptions of the endogenous heavy chain and light chain loci. The transgenic mice can synthesize human antibodies specific for human antigens, and the mice can be used to produce human antibody-secreting hybridomas. Methods for obtaining human antibodies from transgenic mice are described by Green *et al., Nature Genet.* 7:13 (1994), Lonberg *et al., Nature 368*:856 (1994), and Taylor *et al., Int. Immun. 6*:579 (1994). A fully human antibody also can be constructed by genetic or chromosomal transfection methods, as well as phage display technology, all of

which are known in the art. See for example, McCafferty *et al., Nature* 348:552-553 (1990) for the production of human antibodies and fragments thereof *in vitro*, from immunoglobulin variable domain gene repertoires from unimmunized donors. In this technique, antibody variable domain genes are cloned in-frame into either a major or minor coat protein gene of a filamentous bacteriophage, and displayed as functional antibody fragments on the surface of the phage particle. Because the filamentous particle contains a single-stranded DNA copy of the phage genome, selections based on the functional properties of the antibody also result in selection of the gene encoding the antibody exhibiting those properties. In this way, the phage mimics some of the properties of the B cell. Phage display can be performed in a variety of formats, for their review, see e.g. Johnson and Chiswell, *Current Opinion in Structural Biology* 3:5564-571 (1993).

Human antibodies may also be generated by *in vitro* activated B cells. See U.S. Patent Nos. 5,567,610 and 5,229,275, which are incorporated in their entirety by reference.

A therapeutic agent is a molecule or atom which is administered separately, concurrently or sequentially with an antibody moiety or conjugated to an antibody moiety, i.e., antibody or antibody fragment, or a subfragment, and is useful in the treatment of a disease. Examples of therapeutic agents include antibodies, antibody fragments, drugs, toxins, nucleases, hormones, immunomodulators, chelators, boron compounds, photoactive agents or dyes and radioisotopes.

A diagnostic agent is a molecule or atom which is administered conjugated to an antibody moiety, i.e., antibody or antibody fragment, or subfragment, and is useful in diagnosing a disease by locating the cells containing the antigen. Useful diagnostic agents include, but are not limited to, radioisotopes, dyes (such as with the biotin-streptavidin complex), contrast agents, fluorescent compounds or molecules and enhancing agents (e.g. paramagnetic ions) for magnetic resonance imaging (MRI). U.S. Patent No. 6,331,175 describes MRI technique and the preparation of antibodies conjugated to a MRI enhancing agent and is incorporated in its entirety by reference. Preferably, the diagnostic agents are selected from the group consisting of radioisotopes, enhancing agents for use in magnetic resonance imaging, and fluorescent compounds. In order to load an antibody component with radioactive metals or paramagnetic ions, it may be necessary to react it with a reagent having a

long tail to which are attached a multiplicity of chelating groups for binding the ions. Such a tail can be a polymer such as a polylysine, polysaccharide, or other derivatized or derivatizable chain having pendant groups to which can be bound chelating groups such as, *e.g.*, ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA), porphyrins, polyamines, crown ethers, bis-thiosemicarbazones, polyoximes, and like groups known to be useful for this purpose. Chelates are coupled to the peptide antigens using standard chemistries. The chelate is normally linked to the antibody by a group which enables formation of a bond to the molecule with minimal loss of immunoreactivity and minimal aggregation and/or internal cross-linking. other, more unusual, methods and reagents for conjugating chelates to antibodies are disclosed in U.S. Patent 4,824,659 to Hawthorne, entitled "Antibody Conjugates", issued April 25, 1989, the disclosure of which is incorporated herein in its entirety by reference. Particularly useful metal-chelate combinations include 2-benzyl-DTPA and its monomethyl and cyclohexyl analogs, used with diagnostic isotopes in the general energy range of 60 to 4,000 keV, such as ^{125}I, ^{131}I, ^{123}I, ^{124}I, ^{62}Cu, ^{64}Cu, ^{18}F, ^{111}In, ^{67}Ga, ^{68}Ga, ^{99m}Tc, ^{94m}Tc, ^{11}C, ^{13}N, ^{15}O, ^{76}Br , for radio-imaging. The same chelates, when complexed with non-radioactive metals, such as manganese, iron and gadolinium are useful for MRI, when used along with the antibodies of the invention. Macrocyclic chelates such as NOTA, DOTA, and TETA are of use with a variety of metals and radiometals, most particularly with radionuclides of gallium, yttrium and copper, respectively. Such metal-chelate complexes can be made very stable by tailoring the ring size to the metal of interest. Other ring-type chelates such as macrocyclic polyethers, which are of interest for stably binding nuclides, such as ^{223}Ra for RAIT are encompassed by the invention.

An <u>immunoconjugate</u> is a conjugate of an antibody component with a therapeutic or diagnostic agent. The diagnostic agent can comprise a radioactive or non-radioactive label, a contrast agent (such as for magnetic resonance imaging, computed tomography or ultrasound), and the radioactive label can be a gamma-, beta-, alpha-, Auger electron-, or positron-emitting isotope.

An <u>expression vector</u> is a DNA molecules comprising a gene that is expressed in a host cell. Typically, gene expression is placed under the control of certain regulatory elements, including constitutive or inducible promoters, tissue-specific

regulatory elements and enhancers. Such a gene is said to be "operably linked to" the regulatory elements.

A recombinant host may be any prokaryotic or eukaryotic cell that contains either a cloning vector or expression vector. This term also includes those prokaryotic or eukaryotic cells, as well as an transgenic animal, that have been genetically engineered to contain the cloned gene(s) in the chromosome or genome of the host cell or cells of the host cells. Suitable mammalian host cells include myeloma cells, such as SP2/0 cells, and NS0 cells, as well as Chinese Hamster Ovary (CHO) cells, hybridoma cell lines and other mammalian host cell useful for expressing antibodies. Also particularly useful to express mAbs and other fusion proteins, is a human cell line, PER.C6 disclosed in WO 0063403 A2, which produces 2 to 200-fold more recombinant protein as compared to conventional mammalian cell lines, such as CHO, COS, Vero, Hela, BHK and SP2- cell lines. Special transgenic animals with a modified immune system are particularly useful for making fully human antibodies.

As used herein, the term antibody fusion protein is a recombinantly produced antigen-binding molecule in which two or more of the same or different single-chain antibody or antibody fragment segments with the same or different specificities are linked. Valency of the fusion protein indicates how many binding arms or sites the fusion protein has to a single antigen or epitope; i.e., monovalent, bivalent, trivalent or mutlivalent. The multivalency of the antibody fusion protein means that it can take advantage of multiple interactions in binding to an antigen, thus increasing the avidity of binding to the antigen. Specificity indicates how many antigens or epitopes an antibody fusion protein is able to bind; i.e., monospecific, bispecific, trispecific, multispecific. Using these definitions, a natural antibody, e.g., an IgG, is bivalent because it has two binding arms but is monospecific because it binds to one epitope. Monospecific, multivalent fusion proteins have more than one binding site for an epitope but only binds with one epitope, for example a diabody with two binding site reactive with the same antigen. The fusion protein may comprise a single antibody component, a multivalent or multispecific combination of different antibody components or multiple copies of the same antibody component. The fusion protein may additionally comprise an antibody or an antibody fragment and a therapeutic agent. Examples of therapeutic agents suitable for such fusion proteins include immunomodulators ("antibody-immunomodulator fusion protein") and toxins

("antibody-toxin fusion protein"). One preferred toxin comprises a ribonuclease (RNase), preferably a recombinant RNase.

A multispecific antibody is an antibody that can bind simultaneously to at least two targets that are of different structure, *e.g.*, two different antigens, two different epitopes on the same antigen, or a hapten and/or an antigen or epitope. One specificity would be for a B-cell, T-cell, myeloid-, plasma-, and mast-cell antigen or epitope. Another specificity could be to a different antigen on the same cell type, such as CD20, CD19, CD21, CD23, CD46, CD80, HLA-DR, CD74, MUC1, and CD22 on B-cells. Multispecific, multivalent antibodies are constructs that have more than one binding site, and the binding sites are of different specificity. For example, a diabody, where one binding site reacts with one antigen and the other with the other antigen.

A bispecific antibody is an antibody that can bind simultaneously to two targets which are of different structure. Bispecific antibodies (bsAb) and bispecific antibody fragments (bsFab) have at least one arm that specifically binds to, for example, a B-cell, T-cell, myeloid-, plasma-, and mast-cell antigen or epitope and at least one other arm that specifically binds to a targetable conjugate that bears a therapeutic or diagnostic agent. A variety of bispecific fusion proteins can be produced using molecular engineering. In one form, the bispecific fusion protein is monovalent, consisting of, for example, a scFv with a single binding site for one antigen and a Fab fragment with a single binding site for a second antigen. In another form, the bispecific fusion protein is divalent, consisting of, for example, an IgG with a binding site for one antigen and two scFv with two binding sites for a second antigen.

Caninized or felinized antibodies are recombinant proteins in which rodent (or another species) complementarity determining regions of a monoclonal antibody have been transferred from heavy and light variable chains of rodent (or another species) immunoglobulin into a dog or cat, respectively, immunoglobulin variable domain.

Domestic animals include large animals such as horses, cattle, sheep, goats, llamas, alpacas, and pigs, as well as companion animals. In a preferred embodiment, the domestic animal is a horse.

Companion animals include animals kept as pets. These are primarily dogs and cats, although small rodents, such as guinea pigs, hamsters, rats, and ferrets, are

also included, as are subhuman primates such as monkeys. In a preferred embodiment the companion animal is a dog or a cat.

3. Preparation of Monoclonal Antibodies including Chimeric, Humanized and Human Antibodies

Monoclonal antibodies (MAbs) are a homogeneous population of antibodies to a particular antigen and the antibody comprises only one type of antigen binding site and binds to only one epitope on an antigenic determinant. Rodent monoclonal antibodies to specific antigens may be obtained by methods known to those skilled in the art. *See*, for example, Kohler and Milstein, *Nature 256*: 495 (1975), and Coligan *et al.* (eds.), CURRENT PROTOCOLS IN IMMUNOLOGY, VOL. 1, pages 2.5.1-2.6.7 (John Wiley & Sons 1991) [hereinafter "Coligan"]. Briefly, monoclonal antibodies can be obtained by injecting mice with a composition comprising an antigen, verifying the presence of antibody production by removing a serum sample, removing the spleen to obtain B-lymphocytes, fusing the B-lymphocytes with myeloma cells to produce hybridomas, cloning the hybridomas, selecting positive clones which produce antibodies to the antigen, culturing the clones that produce antibodies to the antigen, and isolating the antibodies from the hybridoma cultures.

MAbs can be isolated and purified from hybridoma cultures by a variety of well-established techniques. Such isolation techniques include affinity chromatography with Protein-A Sepharose, size-exclusion chromatography, and ion-exchange chromatography. See, for example, Coligan at pages 2.7.1-2.7.12 and pages 2.9.1-2.9.3. Also, see Baines *et al.*, "Purification of Immunoglobulin G (IgG)," in METHODS IN MOLECULAR BIOLOGY, VOL. 10, pages 79-104 (The Humana Press, Inc. 1992).

After the initial raising of antibodies to the immunogen, the antibodies can be sequenced and subsequently prepared by recombinant techniques. Humanization and chimerization of murine antibodies and antibody fragments are well known to those skilled in the art. For example, humanized monoclonal antibodies are produced by transferring mouse complementary determining regions from heavy and light variable chains of the mouse immunoglobulin into a human variable domain, and then, substituting human residues in the framework regions of the murine counterparts. The

use of antibody components derived from humanized monoclonal antibodies obviates potential problems associated with the immunogenicity of murine constant regions.

General techniques for cloning murine immunoglobulin variable domains are described, for example, by the publication of Orlandi *et al., Proc. Nat'l Acad. Sci. USA 86*: 3833 (1989), which is incorporated by reference in its entirety. Techniques for constructing chimeric antibodies are well known to those of skill in the art. As an example, Leung *et al., Hybridoma 13:*469 (1994), describe how they produced an LL2 chimera by combining DNA sequences encoding the V_κ and V_H domains of LL2 monoclonal antibody, an anti-CD22 antibody, with respective human κ and IgG_1 constant region domains. This publication also provides the nucleotide sequences of the LL2 light and heavy chain variable regions, V_κ and V_H, respectively. Techniques for producing humanized MAbs are described, for example, by Jones *et al., Nature 321*: 522 (1986), Riechmann *et al., Nature 332*: 323 (1988), Verhoeyen *et al., Science 239*: 1534 (1988), Carter *et al., Proc. Nat'l Acad. Sci. USA 89*: 4285 (1992), Sandhu, *Crit. Rev. Biotech. 12*: 437 (1992), and Singer *et al., J. Immun. 150*: 2844 (1993), each of which is hereby incorporated by reference.

A chimeric antibody is a recombinant protein that contains the variable domains including the CDRs derived from one species of animal, such as a rodent antibody, while the remainder of the antibody molecule; i.e., the constant domains, is derived from a human antibody. Accordingly, a chimeric monoclonal antibody can also be humanized by replacing the sequences of the murine FR in the variable domains of the chimeric MAb with one or more different human FR. Specifically, mouse CDRs are transferred from heavy and light variable chains of the mouse immunoglobulin into the corresponding variable domains of a human antibody. As simply transferring mouse CDRs into human FRs often results in a reduction or even loss of antibody affinity, additional modification might be required in order to restore the original affinity of the murine antibody. This can be accomplished by the replacement of one or more some human residues in the FR regions with their murine counterparts to obtain an antibody that possesses good binding affinity to its epitope. See, for example, Tempest *et al., Biotechnology* 9:266 (1991) and Verhoeyen *et al., Science* 239: 1534 (1988). Further, the affinity of humanized, chimeric and human MAbs to a specific epitope can be increased by mutagenesis of the CDRs, so that a lower dose of antibody may be as

effective as a higher dose of a lower affinity MAb prior to mutagenesis. See for example, WO0029584A1

Another method for producing the antibodies of the present invention is by production in the milk of transgenic livestock. See, e.g., Colman, A., *Biochem. Soc. Symp.*, 63: 141-147, 1998; U.S. Patent 5,827,690, both of which are incorporated in their entirety by reference. Two DNA constructs are prepared which contain, respectively, DNA segments encoding paired immunoglobulin heavy and light chains. The DNA segments are cloned into expression vectors which contain a promoter sequence that is preferentially expressed in mammary epithelial cells. Examples include, but are not limited to, promoters from rabbit, cow and sheep casein genes, the cow α-lactoglobulin gene, the sheep β-lactoglobulin gene and the mouse whey acid protein gene. Preferably, the inserted fragment is flanked on its 3' side by cognate genomic sequences from a mammary-specific gene. This provides a polyadenylation site and transcript-stabilizing sequences. The expression cassettes are co-injected into the pronuclei of fertilized, mammalian eggs, which are then implanted into the uterus of a recipient female and allowed to gestate. After birth, the progeny are screened for the presence of both transgenes by Southern analysis. In order for the antibody to be present, both heavy and light chain genes must be expressed concurrently in the same cell. Milk from transgenic females is analyzed for the presence and functionality of the antibody or antibody fragment using standard immunological methods known in the art. The antibody can be purified from the milk using standard methods known in the art.

A fully human antibody of the present invention, i.e., human anti-CD20 MAbs or other human antibodies, such as anti-CD22, anti-CD19, anti-CD23, or anti-CD21 MAbs for combination therapy with humanized, chimeric or human anti-CD20 antibodies, can be obtained from a transgenic non-human animal. See, e.g., Mendez *et al.*, *Nature Genetics*, 15: 146-156 (1997); U.S. Patent No. 5,633,425, which are incorporated in their entirety by reference. For example, a human antibody can be recovered from a transgenic mouse possessing human immunoglobulin loci. The mouse humoral immune system is humanized by inactivating the endogenous immunoglobulin genes and introducing human immunoglobulin loci. The human immunoglobulin loci are exceedingly complex and comprise a large number of discrete segments which together occupy almost 0.2% of the human genome. To

ensure that transgenic mice are capable of producing adequate repertoires of antibodies, large portions of human heavy- and light-chain loci must be introduced into the mouse genome. This is accomplished in a stepwise process beginning with the formation of yeast artificial chromosomes (YACs) containing either human heavy- or light-chain immunoglobulin loci in germline configuration. Since each insert is approximately 1 Mb in size, YAC construction requires homologous recombination of overlapping fragments of the immunoglobulin loci. The two YACs, one containing the heavy-chain loci and one containing the light-chain loci, are introduced separately into mice via fusion of YAC-containing yeast spheroblasts with mouse embryonic stem cells. Embryonic stem cell clones are then microinjected into mouse blastocysts. Resulting chimeric males are screened for their ability to transmit the YAC through their germline and are bred with mice deficient in murine antibody production. Breeding the two transgenic strains, one containing the human heavy-chain loci and the other containing the human light-chain loci, creates progeny which produce human antibodies in response to immunization.

Further recent methods for producing bispecific mAbs include engineered recombinant mAbs which have additional cysteine residues so that they crosslink more strongly than the more common immunoglobulin isotypes. See, e.g., FitzGerald *et al.*, Protein Eng. 10(10):1221-1225, 1997. Another approach is to engineer recombinant fusion proteins linking two or more different single-chain antibody or antibody fragment segments with the needed dual specificities. See, e.g., Coloma *et al.*, *Nature Biotech.* 15:159-163, 1997. A variety of bispecific fusion proteins can be produced using molecular engineering. In one form, the bispecific fusion protein is monovalent, consisting of, for example, a scFv with a single binding site for one antigen and a Fab fragment with a single binding site for a second antigen. In another form, the bispecific fusion protein is divalent, consisting of, for example, an IgG with two binding sites for one antigen and two scFv with two binding sites for a second antigen.

Bispecific fusion proteins linking two or more different single-chain antibodies or antibody fragments are produced in similar manner. Recombinant methods can be used to produce a variety of fusion proteins. For example a fusion protein comprising a Fab fragment derived from a humanized monoclonal anti-CD20 antibody and a scFv derived from a murine anti-diDTPA can be produced. A flexible

linker, such as GGGS connects the scFv to the constant region of the heavy chain of the anti-CD20 antibody. Alternatively, the scFv can be connected to the constant region of the light chain of another humanized antibody. Appropriate linker sequences necessary for the in-frame connection of the heavy chain Fd to the scFv are introduced into the VL and VK domains through PCR reactions. The DNA fragment encoding the scFv is then ligated into a staging vector containing a DNA sequence encoding the CH1 domain. The resulting scFv-CH1 construct is excised and ligated into a vector containing a DNA sequence encoding the VH region of an anti-CD20 antibody. The resulting vector can be used to transfect an appropriate host cell, such as a mammalian cell for the expression of the bispecific fusion protein.

4. Production of Antibody Fragments

Antibody fragments which recognize specific epitopes can be generated by known techniques. The antibody fragments are antigen binding portions of an antibody, such as $F(ab')_2$, Fab', Fab, Fv, sFv and the like. Other antibody fragments include, but are not limited to: the $F(ab)'_2$ fragments which can be produced by pepsin digestion of the antibody molecule and the Fab′ fragments, which can be generated by reducing disulfide bridges of the $F(ab)'_2$ fragments. Alternatively, Fab′ expression libraries can be constructed (Huse *et al.*, 1989, *Science*, 246:1274-1281) to allow rapid and easy identification of monoclonal Fab′ fragments with the desired specificity. The present invention encompasses antibodies and antibody fragments.

A single chain Fv molecule (scFv) comprises a VL domain and a VH domain. The VL and VH domains associate to form a target binding site. These two domains are further covalently linked by a peptide linker (L). A scFv molecule is denoted as either VL-L-VH if the VL domain is the N-terminal part of the scFv molecule, or as VH-L-VL if the VH domain is the N-terminal part of the scFv molecule. Methods for making scFv molecules and designing suitable peptide linkers are described in US Patent No. 4,704,692, US Patent No. 4,946,778, R. Raag and M. Whitlow, "*Single Chain Fvs.*" FASEB Vol 9:73-80 (1995) and R.E. Bird and B.W. Walker, "*Single Chain Antibody Variable Regions*," TIBTECH, Vol 9: 132-137 (1991). These references are incorporated herein by reference.

An antibody fragment can be prepared by proteolytic hydrolysis of the full length antibody or by expression in *E. coli* or another host of the DNA coding for the

fragment. An antibody fragment can be obtained by pepsin or papain digestion of full length antibodies by conventional methods. For example, an antibody fragment can be produced by enzymatic cleavage of antibodies with pepsin to provide a 5S fragment denoted $F(ab')_2$. This fragment can be further cleaved using a thiol reducing agent, and optionally a blocking group for the sulfhydryl groups resulting from cleavage of disulfide linkages, to produce 3.5S Fab' monovalent fragments. Alternatively, an enzymatic cleavage using papain produces two monovalent Fab fragments and an Fc fragment directly. These methods are described, for example, by Goldenberg, U.S. Patent Nos. 4,036,945 and 4,331,647 and references contained therein, which patents are incorporated herein in their entireties by reference. Also, see Nisonoff *et al., Arch Biochem. Biophys. 89*: 230 (1960); Porter, *Biochem. J. 73*: 119 (1959), Edelman *et al.,* in METHODS IN ENZYMOLOGY VOL. 1, page 422 (Academic Press 1967), and Coligan at pages 2.8.1-2.8.10 and 2.10.-2.10.4.

Another form of an antibody fragment is a peptide coding for a single complementarity-determining region (CDR). A CDR is a segment of the variable region of an antibody that is complementary in structure to the epitope to which the antibody binds and is more variable than the rest of the variable region. Accordingly, a CDR is sometimes referred to as hypervariable region. A variable region comprises three CDRs. CDR peptides can be obtained by constructing genes encoding the CDR of an antibody of interest. Such genes are prepared, for example, by using the polymerase chain reaction to synthesize the variable region from RNA of antibody-producing cells. See, for example, Larrick *et al., Methods: A Companion to Methods in Enzymology 2*: 106 (1991); Courtenay-Luck, "Genetic Manipulation of Monoclonal Antibodies," in MONOCLONAL ANTIBODIES: PRODUCTION, ENGINEERING AND CLINICAL APPLICATION, Ritter *et al.* (eds.), pages 166-179 (Cambridge University Press 1995); and Ward *et al.,* "Genetic Manipulation and Expression of Antibodies," in MONOCLONAL ANTIBODIES: PRINCIPLES AND APPLICATIONS, Birch *et al.*, (eds.), pages 137-185 (Wiley-Liss, Inc. 1995).

Other methods of cleaving antibodies, such as separation of heavy chains to form monovalent light-heavy chain fragments, further cleavage of fragments, or other enzymatic, chemical or genetic techniques may also be used, so long as the fragments bind to the antigen that is recognized by the intact antibody.

5. Multispecific and multivalent antibodies

The anti-CD20 antibodies, as well as other antibodies with different specificities for use in combination therapy, described herein, can also be made as multispecific antibodies (comprising at least one binding site to a CD20 epitope or antigen and at least one binding site to another epitope on CD20 or another antigen) and multivalent antibodies (comprising multiple binding sites to the same epitope or antigen). Multivalent target binding proteins are described in US Serial No. 09/911,610 (Leung *et al.*), which is incorporated herein by reference in its entirety.

The present invention provides a bispecific antibody or antibody fragment having at least a binding region that specifically binds a targeted cell marker and at least one other binding region that specifically binds a targetable conjugate. The targetable conjugate comprises a carrier portion which comprises or bears at least one epitope recognized by at least one binding region of the bispecific antibody or antibody fragment.

A variety of recombinant methods can be used to produce bispecific antibodies and antibody fragments as described above.

An anti-CD20 multivalent antibody is also contemplated in the present invention. This multivalent target binding protein is constructed by association of a first and a second polypeptide. The first polypeptide comprises a first single chain Fv molecule covalently linked to a first immunoglobulin-like domain which preferably is an immunoglobulin light chain variable region domain. The second polypeptide comprises a second single chain Fv molecule covalently linked to a second immunoglobulin-like domain which preferably is an immunoglobulin heavy chain variable region domain. Each of the first and second single chain Fv molecules forms a target binding site, and the first and second immunoglobulin-like domains associate to form a third target binding site.

A single chain Fv molecule with the VL-L-VH configuration, wherein L is a linker, may associate with another single chain Fv molecule with the VH-L-VL configuration to form a bivalent dimer. In this case, the VL domain of the first scFv and the VH domain of the second scFv molecule associate to form one target binding site, while the VH domain of the first scFv and the VL domain of the second scFv associate to form the other target binding site.

Another embodiment of the present invention is a CD20 bispecific, trivalent targeting protein comprising two heterologous polypeptide chains associated non-covalently to form three binding sites, two of which have affinity for one target and a third which has affinity for a hapten that can be made and attached to a carrier for a diagnostic and/or therapeutic agent. Preferably, the binding protein has two CD20 binding sites and one CD22 binding site. The bispecific, trivalent targeting agents have two different scFvs, one scFv contains two V_H domains from one antibody connected by a short linker to the V_L domain of another antibody and the second scFv contains two V_L domains from the first antibody connected by a short linker to the V_H domain of the other antibody. The methods for generating multivalent, multispecific agents from V_H and V_L domains provide that individual chains synthesized from a DNA plasmid in a host organism are composed entirely of V_H domains (the V_H-chain) or entirely of V_L domains (the V_L-chain) in such a way that any agent of multivalency and multispecificity can be produced by non-covalent association of one V_H-chain with one V_L-chain. For example, forming a trivalent, trispecific agent, the V_H-chain will consist of the amino acid sequences of three V_H domains, each from an antibody of different specificity, joined by peptide linkers of variable lengths, and the V_L-chain will consist of complementary V_L domains, joined by peptide linkers similar to those used for the V_H-chain. Since the V_H and V_L domains of antibodies associate in an anti-parallel fashion, the preferred method in this invention has the V_L domains in the V_L-chain arranged in the reverse order of the V_H domains in the V_H-chain.

6. Diabodies, Triabodies and Tetrabodies

The anti-CD20 antibodies of the present invention can also be used to prepare functional bispecific single-chain antibodies (bscAb), also called diabodies, and can be produced in mammalian cells using recombinant methods. See, e.g., Mack *et al.*, *Proc. Natl. Acad. Sci.*, 92: 7021-7025, 1995, incorporated. For example, bscAb are produced by joining two single-chain Fv fragments via a glycine-serine linker using recombinant methods. The V light-chain (V_L) and V heavy-chain (V_H) domains of two antibodies of interest are isolated using standard PCR methods. The V_L and V_H cDNA's obtained from each hybridoma are then joined to form a single-chain fragment in a two-step fusion PCR. The first PCR step introduces the $(Gly_4\text{-}Ser_1)_3$ linker, and the second step joins the V_L and V_H amplicons. Each single chain

molecule is then cloned into a bacterial expression vector. Following amplification, one of the single-chain molecules is excised and sub-cloned into the other vector, containing the second single-chain molecule of interest. The resulting bscAb fragment is subcloned into an eukaryotic expression vector. Functional protein expression can be obtained by transfecting the vector into chinese hamster ovary cells. Bispecific fusion proteins are prepared in a similar manner. Bispecific single-chain antibodies and bispecific fusion proteins are included within the scope of the present invention.

For example, a humanized, chimeric or human anti-CD20 monoclonal antibody can be used to produce antigen specific diabodies, triabodies, and tetrabodies. The monospecific diabodies, triabodies, and tetrabodies bind selectively to targeted antigens and as the number of binding sites on the molecule increases, the affinity for the target cell increases and a longer residence time is observed at the desired location. For diabodies, the two chains comprising the V_H polypeptide of the humanized CD20 MAb connected to the V_K polypeptide of the humanized CD20 MAb by a five amino acid residue linker are utilized. Each chain forms one half of the humanized CD20 diabody. In the case of triabodies, the three chains comprising V_H polypeptide of the humanized CD20 MAb connected to the V_K polypeptide of the humanized CD20 MAb by no linker are utilized. Each chain forms one third of the hCD20 triabody.

The ultimate use of the bispecific diabodies described herein is for pre-targeting CD20 positive tumors for subsequent specific delivery of diagnostic or therapeutic agents. These diabodies bind selectively to targeted antigens allowing for increased affinity and a longer residence time at the desired location. Moreover, non-antigen bound diabodies are cleared from the body quickly and exposure of normal tissues is minimized. Bispecific antibody point mutations for enhancing the rate of clearance can be found in US Provisional Application No. 60/361,037 to Qu *et al.* (Atty Docket No. 18733/1037), which is incorporated herein by reference in its entirety. Bispecific diabodies for affinity enhancement are disclosed in US Application Nos. 10/270,071 (Rossi *et al.*), 10/270,073 (Rossi *et al.*) and 10/328,190 (Rossi *et al.*), which are incorporated herein by reference in their entirety. The diagnostic and therapeutic agents can include isotopes, drugs, toxins, cytokines, hormones, growth factors, conjugates, radionuclides, and metals. For example,

gadolinium metal is used for magnetic resonance imaging (MRI). Examples of radionuclides are ^{225}Ac, ^{18}F, ^{68}Ga, ^{67}Ga, ^{90}Y, ^{86}Y, ^{111}In, ^{131}I, ^{125}I, ^{123}I, ^{99m}Tc, ^{94m}Tc, ^{186}Re, ^{188}Re, ^{177}Lu, ^{62}Cu, ^{64}Cu, ^{67}Cu, ^{212}Bi, ^{213}Bi, ^{32}P, ^{11}C, ^{13}N, ^{15}O, ^{76}Br, and ^{211}At. Other radionuclides are also available as diagnostic and therapeutic agents, especially those in the energy range of 60 to 4,000 keV.

More recently, a tetravalent tandem diabody (termed tandab) with dual specificity has also been reported (Cochlovius et al., Cancer Research (2000) 60: 4336-4341). The bispecific tandab is a dimer of two identical polypeptides, each containing four variable domains of two different antibodies (V_{H1}, V_{L1}, V_{H2}, V_{L2}) linked in an orientation to facilitate the formation of two potential binding sites for each of the two different specificities upon self-association.

7. Conjugated multivalent and multispecific anti-CD20 antibodies

In another embodiment of the instant invention is a conjugated multivalent anti-CD20 antibody. Additional amino acid residues may be added to either the N- or C-terminus of the first or the second polypeptide. The additional amino acid residues may comprise a peptide tag, a signal peptide, a cytokine, an enzyme (for example, a pro-drug activating enzyme), a hormone, a peptide toxin, such as pseudomonas extoxin, a peptide drug, a cytotoxic protein or other functional proteins. As used herein, a functional protein is a protein which has a biological function.

In one embodiment, drugs, toxins, radioactive compounds, enzymes, hormones, cytotoxic proteins, chelates, cytokines and other functional agents may be conjugated to the multivalent target binding protein, preferably through covalent attachments to the side chains of the amino acid residues of the multivalent target binding protein, for example amine, carboxyl, phenyl, thiol or hydroxyl groups. Various conventional linkers may be used for this purpose, for example, diisocyanates, diisothiocyanates, bis(hydroxysuccinimide) esters, carbodiimides, maleimide-hydroxysuccinimide esters, glutaraldehyde and the like. Conjugation of agents to the multivalent protein preferably does not significantly affect the protein's binding specificity or affinity to its target. As used herein, a functional agent is an agent which has a biological function. A preferred functional agent is a cytotoxic agent.

In still other embodiments, bispecific antibody-directed delivery of therapeutics or prodrug polymers to *in vivo* targets can be combined with bispecific antibody delivery of radionuclides, such that combination chemotherapy and radioimmunotherapy is achieved. Each therapy can be conjugated to the targetable conjugate and administered simultaneously, or the nuclide can be given as part of a first targetable conjugate and the drug given in a later step as part of a second targetable conjugate.

In another embodiment, cytotoxic agents may be conjugated to a polymeric carrier, and the polymeric carrier may subsequently be conjugated to the multivalent target binding protein. For this method, see Ryser et al., *Proc. Natl. Acad. Sci. USA*, 75:3867-3870, 1978, US Patent No. 4,699,784 and US Patent No. 4,046,722, which are incorporated herein by reference. Conjugation preferably does not significantly affect the binding specificity or affinity of the multivalent binding protein.

8. Humanized, Chimeric and Human Antibodies Use for Treatment and Diagnosis

Humanized, chimeric and human monoclonal antibodies, i.e., anti-CD20 MAbs and other MAbs described herein, in accordance with this invention are suitable for use in therapeutic methods and diagnostic methods. Accordingly, the present invention contemplates the administration of the humanized, chimeric and human antibodies of the present invention alone as a naked antibody or administered as a multimodal therapy, temporally according to a dosing regimen, but not conjugated to, a therapeutic agent. The efficacy of the naked anti-CD20 MAbs can be enhanced by supplementing naked antibodies with one or more other naked antibodies, i.e., MAbs to specific antigens, such as CD4, CD5, CD8, CD14, CD15, CD19, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, or HLA-DR, tenascin, VEGF, PlGF, an oncogene, an oncogene product, or a combination thereofwith one or more immunoconjugates of anti-CD20, or antibodies to theses recited antigens, conjugated with therapeutic agents, including drugs, toxins, immunomodulators, hormones, therapeutic radionuclides, etc., with one or more therapeutic agents, including drugs, toxins, immunomodulators, hormones, therapeutic radionuclides, etc., administered concurrently or sequentially or according to a prescribed dosing regimen, with the MAbs. Preferred B-cell antigens include those

equivalent to human CD19, CD20, CD21, CD22, CD23, CD46, CD52, CD74, CD80, and CD5 antigens. Preferred T-cell antigens include those equivalent to human CD4, CD8 and CD25 (the IL-2 receptor) antigens. An equivalent to HLA-DR antigen can be used in treatment of both B-cell and T-cell disorders. Particularly preferred B-cell antigens are those equivalent to human CD19, CD22, CD21, CD23, CD74, CD80, and HLA-DR antigens. Particularly preferred T-cell antigens are those equivalent to human CD4, CD8 and CD25 antigens. CD46 is an antigen on the surface of cancer cells that block complement-dependent lysis (CDC).

Further, the present invention contemplates the administration of an immunoconjugate for diagnostic and therapeutic uses in B cell lymphomas and other disease or disorders. An immunoconjugate, as described herein, is a molecule comprising an antibody component and a therapeutic or diagnostic agent, including a peptide which may bear the diagnostic or therapeutic agent. An immunoconjugate retains the immunoreactivity of the antibody component, i.e., the antibody moiety has about the same or slightly reduced ability to bind the cognate antigen after conjugation as before conjugation.

A wide variety of diagnostic and therapeutic agents can be advantageously conjugated to the antibodies of the invention. The therapeutic agents recited here are those agents that also are useful for administration separately with the naked antibody as described above. Therapeutic agents include, for example, chemotherapeutic drugs such as vinca alkaloids, anthracyclines, epidophyllotoxin, taxanes, antimetabolites, alkylating agents, antikinase agents, antibiotics, Cox-2 inhibitors, antimitotics, antiangiogenic and apoptotoic agents, particularly doxorubicin, methotrexate, taxol, CPT-11, camptothecans, and others from these and other classes of anticancer agents , and the like. Other useful cancer chemotherapeutic drugs for the preparation of immunoconjugates and antibody fusion proteins include nitrogen mustards, alkyl sulfonates, nitrosoureas, triazenes, folic acid analogs, COX-2 inhibitors, pyrimidine analogs, purine analogs, platinum coordination complexes, hormones, and the like. Suitable chemotherapeutic agents are described in REMINGTON'S PHARMACEUTICAL SCIENCES, 19th Ed. (Mack Publishing Co. 1995), and in GOODMAN AND GILMAN'S THE PHARMACOLOGICAL BASIS OF THERAPEUTICS, 7th Ed. (MacMillan Publishing Co. 1985), as well as revised

editions of these publications. Other suitable chemotherapeutic agents, such as experimental drugs, are known to those of skill in the art.

Additionally, a chelator such as DTPA, DOTA, TETA, or NOTA or a suitable peptide, to which a detectable label, such as a fluorescent molecule, or cytotoxic agent, such as a heavy metal or radionuclide, can be conjugated. For example, a therapeutically useful immunoconjugate can be obtained by conjugating a photoactive agent or dye to an antibody composite. Fluorescent compositions, such as fluorochrome, and other chromogens, or dyes, such as porphyrins sensitive to visible light, have been used to detect and to treat lesions by directing the suitable light to the lesion. In therapy, this has been termed photoradiation, phototherapy, or photodynamic therapy (Jori *et al.* (eds.), PHOTODYNAMIC THERAPY OF TUMORS AND OTHER DISEASES (Libreria Progetto 1985); van den Bergh, *Chem. Britain 22*:430 (1986)). Moreover, monoclonal antibodies have been coupled with photoactivated dyes for achieving phototherapy. Mew *et al., J. Immunol. 130*:1473 (1983); *idem., Cancer Res. 45*:4380 (1985); Oseroff *et al., Proc. Natl. Acad. Sci. USA 83*:8744 (1986); *idem., Photochem. Photobiol. 46*:83 (1987); Hasan *et al., Prog. Clin. Biol. Res. 288*:471 (1989); Tatsuta *et al., Lasers Surg. Med. 9*:422 (1989); Pelegrin *et al., Cancer 67*:2529 (1991). However, these earlier studies did not include use of endoscopic therapy applications, especially with the use of antibody fragments or subfragments. Thus, the present invention contemplates the therapeutic use of immunoconjugates comprising photoactive agents or dyes.

Also contemplated by the present invention are the use of radioactive and non-radioactive agents as diagnostic agents. A suitable non-radioactive diagnostic agent is a contrast agent suitable for magnetic resonance imaging, computed tomography or ultrasound. Magnetic imaging agents include, for example, non-radioactive metals, such as manganese, iron and gadolinium, complexed with metal-chelate combinations that include 2-benzyl-DTPA and its monomethyl and cyclohexyl analogs, when used along with the antibodies of the invention. See U.S. Serial No. 09/921,290 filed on October 10, 2001, which is incorporated in its entirety by reference.

Furthermore, a radiolabeled antibody or immunoconjugate may comprise a γ-emitting radioisotope or a positron-emitter useful for diagnostic imaging. Suitable radioisotopes, particularly in the energy range of 60 to 4,000keV, include ^{131}I, ^{123}I, ^{124}I, ^{86}Y, ^{62}Cu, ^{64}Cu, ^{111}In, ^{67}Ga, ^{68}Ga, ^{99m}Tc, ^{94m}Tc, ^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{75}Br, and the

like. See for example, U.S. Patent Application entitled "Labeling Targeting Agents with Gallium-68"- Inventors G.L.Griffiths and W.J. McBride, (U.S. Provisional Application No. 60/342,104), which discloses positron emitters, such as ^{18}F, ^{68}Ga, ^{94m}Tc. and the like, for imaging purposes and which is incorporated in its entirety by reference. Particularly useful therapeutic radionuclides include, but are not limited to, ^{32}P, ^{33}P, ^{47}Sc, ^{64}Cu, ^{67}Cu, ^{67}Ga, ^{90}Y, ^{111}Ag, ^{111}In, ^{125}I, ^{131}I, ^{142}Pr, ^{153}Sm, ^{161}Tb, ^{166}Dy, ^{166}Ho, ^{177}Lu, ^{186}Re, ^{188}Re, ^{189}Re, ^{212}Pb, ^{212}Bi, ^{213}Bi, ^{211}At, ^{223}Ra and ^{225}Ac. Particularly useful diagnostic/detection radionuclides include, but are not limited to, ^{18}F, ^{52}Fe, ^{62}Cu, ^{64}Cu, ^{67}Cu, ^{67}Ga, ^{68}Ga, ^{86}Y, ^{89}Zr, ^{94m}Tc, ^{94}Tc, ^{99m}Tc, ^{111}In, ^{123}I, ^{124}I, ^{125}I, ^{131}I, $^{154-158}Gd$, ^{32}P, ^{90}Y, ^{188}Re, and ^{175}Lu.

A toxin, such as *Pseudomonas* exotoxin, may also be complexed to or form the therapeutic agent portion of an antibody fusion protein of an anti-CD20 antibody of the present invention. Other toxins suitably employed in the preparation of such conjugates or other fusion proteins, include ricin, abrin, ribonuclease (RNase), DNase I, *Staphylococcal* enterotoxin-A, pokeweed antiviral protein, gelonin, diphtherin toxin, *Pseudomonas* exotoxin, and *Pseudomonas* endotoxin. See, for example, Pastan *et al., Cell 47*:641 (1986), and Goldenberg, *CA - A Cancer Journal for Clinicians 44*:43 (1994). Additional toxins suitable for use in the present invention are known to those of skill in the art and are disclosed in U.S. Patent 6,077,499, which is incorporated in its entirety by reference.

An immunomodulator, such as a cytokine may also be conjugated to, or form the therapeutic agent portion of an antibody fusion protein or be administered with the humanized anti-CD20 antibodies of the present invention. Suitable cytokines for the present invention include, but are not limited to, interferons and interleukins, as described below.

An oligonucleotide, such the antisense molecules inhibiting bcl-2 expression that are described in U.S. 5,734,033 (Reed) which is incorporated by reference in its entirety, may also be conjugated to, or form the therapeutic agent portion of an antibody fusion protein or be administered with the humanized anti-CD20 antibodies of the present invention.

9. Preparation of Immunoconjugates

Any of the antibodies or antibody fusion proteins of the present invention can be conjugated with one or more therapeutic or diagnostic agents. Generally, one therapeutic or diagnostic agent is attached to each antibody or antibody fragment but more than one therapeutic agent or diagnostic agent can be attached to the same antibody or antibody fragment. The antibody fusion proteins of the present invention comprise two or more antibodies or fragments thereof and each of the antibodies that composes this fusion protein can contain a therapeutic agent or diagnostic agent. Additionally, one or more of the antibodies of the antibody fusion protein can have more than one therapeutic of diagnostic agent attached. Further, the therapeutic agents do not need to be the same but can be different therapeutic agents. For example, one can attach a drug and a radioisotope to the same fusion protein. Particularly, an IgG can be radiolabeled with ^{131}I and attached to a drug. The ^{131}I can be incorporated into the tyrosine of the IgG and the drug attached to the epsilon amino group of the IgG lysines. Both therapeutic and diagnostic agents also can be attached to reduced SH groups and to the carbohydrate side chains.

Radionuclides suitable for treating a disease tissue substantially decay by beta-particle emission and include, but are not limited to: ^{32}P, ^{33}P, ^{47}Sc, ^{59}Fe, ^{64}Cu, ^{67}Cu, ^{75}Se, ^{77}As, ^{89}Sr, ^{90}Y, ^{99}Mo, ^{105}Rh, ^{109}Pd, ^{111}Ag, ^{125}I, ^{131}I, ^{142}Pr, ^{143}Pr, ^{149}Pm, ^{153}Sm, ^{161}Tb, ^{166}Ho, ^{169}Er, ^{177}Lu, ^{186}Re, ^{188}Re, ^{189}Re, ^{194}Ir, ^{198}Au, ^{199}Au, ^{211}Pb, ^{212}Pb and ^{213}Bi. Maximum decay energies of useful beta-particle-emitting nuclides are preferably 20-5,000 keV, more preferably 100-4,000 keV, and most preferably 500-2,500 keV. Also preferred are radionuclides that substantially decay with Auger-emitting particles. For example, ^{58}Co, ^{67}Ga, ^{80m}Br, ^{99m}Tc, ^{103m}Rh, ^{109}Pt, ^{111}In, ^{119}Sb, ^{125}I, ^{161}Ho, ^{189m}Os and ^{192}Ir. Decay energies of useful Auger-particle-emitting nuclides are preferably $< 1,000$ keV, more preferably < 100 keV, and most preferably < 70 keV. Also preferred are radionuclides that substantially decay with generation of alpha-particles. Such radionuclides include, but are not limited to: ^{152}Dy, ^{211}At, ^{212}Bi, ^{223}Ra, ^{219}Rn, ^{215}Po, ^{211}Bi, ^{225}Ac, ^{221}Fr, ^{217}At, ^{213}Bi and ^{255}Fm. Decay energies of useful alpha-particle-emitting radionuclides are preferably 2,000-10,000 keV, more preferably 3,000-8,000 keV, and most preferably 4,000-7,000 keV.

Radionuclides useful as diagnostic agents utilizing gamma-ray detection include, but are not limited to: ^{51}Cr, ^{57}Co, ^{58}Co, ^{59}Fe, ^{67}Cu, ^{67}Ga, ^{75}Se, ^{97}Ru, ^{99m}Tc,

^{111}In, ^{114m}In, ^{123}I, 125I, ^{131}I, ^{169}Yb, ^{197}Hg, and ^{201}Tl. Decay energies of useful gamma-ray emitting radionuclides are preferably 20-2000 keV, more preferably 60-600 keV, and most preferably 100-300 keV.

Radionuclides useful for positron emission tomography include, but are not limited to: ^{18}F, ^{51}Mn, ^{52m}Mn, ^{52}Fe, ^{55}Co, ^{62}Cu, ^{64}Cu, ^{68}Ga, ^{72}As, ^{75}Br, ^{76}Br, ^{82m}Rb, ^{83}Sr, ^{86}Y, ^{89}Zr, 94mTc, ^{110}In, ^{120}I, and ^{124}I. Total decay energies of useful positron-emitting radionuclides are preferably < 2,000 keV, more preferably under 1,000 keV, and most preferably < 700 keV.

Bispecific antibodies of the present invention are useful in pretargeting methods and provide a preferred way to deliver two therapeutic agents or two diagnostic agents to a subject. U.S. Serial Nos. 09/382,186 and 09/337,756 discloses a method of pretargeting using a bispecific antibody, in which the bispecific antibody is labeled with ^{125}I and delivered to a subject, followed by a divalent peptide labeled with ^{99m}Tc, and are incorporated herein by reference in their entirety. Pretargeting methods are also described in US Serial Nos. 09/823,746 (Hansen *et al.*) and 10/150,654 (Goldenberg *et al.*), and US Provisional Application filed January 31, 2003, entitled "Methods and Compositions for Administration of Therapeutic and Diagnostic Agents, Atty Docket No. 018733/1103 (McBride *et al.*), which are all also incorporated herein by reference in their entirety. The delivery results in excellent tumor/normal tissue ratios for ^{125}I and ^{99m}Tc, thus showing the utility of two diagnostic radioisotopes. Any combination of known therapeutic agents or diagnostic agents can be used to label the antibodies and antibody fusion proteins. The binding specificity of the antibody component of the MAb conjugate, the efficacy of the therapeutic agent or diagnostic agent and the effector activity of the Fc portion of the antibody can be determined by standard testing of the conjugates.

The invention is directed to a method for pretargeting a cell in a patients suffering from a B-cell lymphoma or leukemia or an autoimmune disease comprising:

(i) administering an antibody fusion protein or fragment thereof that is multispecific having at least one arm that specifically binds the cell and at least one other arm that specifically binds a targetable conjugate; (ii) optionally, administering to the patient a clearing composition, and allowing the composition to clear non-antigen bound antibody fusion protein or fragment thereof from circulation; and (iii) administering to the patient a targetable conjugate comprising a carrier portion which

comprises or bears at least one epitope recognizable by at least one other arm of the antibody fusion protein or fragment thereof, and is conjugated at least one first therapeutic or diagnostic agent. The antibody fusion protein of the present invention should be multispecific antibody. In a preferred embodiment the antibody is a bispecific antibody, and can be a diabody. The first therapeutic agent is selected from the group consisting of a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, a cytotoxic agent, an oligonucleotide and a combination thereof and wherein the first diagnostic agent is at least one of a radioactive label, a photoactive diagnostic agent or a non-radioactive label.

The antibody fusion protein or fragment thereof also may be conjugated to a second therapeutic, such as at least one radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, a cytotoxic agent, an oligonucleotide and a combination thereof or may be conjugated the second diagnostic agent, such as at least one of a radioactive label, a photoactive diagnostic agent or a non-radioactive label. In one embodiment, the first and second therapeutic agent or diagnostic agent are the same.

A therapeutic or diagnostic agent can be attached at the hinge region of a reduced antibody component via disulfide bond formation. As an alternative, such peptides can be attached to the antibody component using a heterobifunctional cross-linker, such as *N*-succinyl 3-(2-pyridyldithio)propionate (SPDP). Yu *et al., Int. J. Cancer 56*: 244 (1994). General techniques for such conjugation are well-known in the art. See, for example, Wong, CHEMISTRY OF PROTEIN CONJUGATION AND CROSS-LINKING (CRC Press 1991); Upeslacis *et al.*, "Modification of Antibodies by Chemical Methods," in MONOCLONAL ANTIBODIES: PRINCIPLES AND APPLICATIONS, Birch *et al.* (eds.), pages 187-230 (Wiley-Liss, Inc. 1995); Price, "Production and Characterization of Synthetic Peptide-Derived Antibodies," in MONOCLONAL ANTIBODIES: PRODUCTION, ENGINEERING AND CLINICAL APPLICATION, Ritter *et al.* (eds.), pages 60-84 (Cambridge University Press 1995). Alternatively, the therapeutic or diagnostic agent can be conjugated via a carbohydrate moiety in the Fc region of the antibody. The carbohydrate group can be used to increase the loading of the same peptide that is bound to a thiol group, or the carbohydrate moiety can be used to bind a different peptide.

Methods for conjugating peptides to antibody components via an antibody carbohydrate moiety are well-known to those of skill in the art. See, for example, Shih *et al., Int. J. Cancer 41*: 832 (1988); Shih *et al., Int. J. Cancer 46*: 1101 (1990); and Shih *et al.*, U.S. Patent No. 5,057,313, all of which are incorporated in their entirety by reference. The general method involves reacting an antibody component having an oxidized carbohydrate portion with a carrier polymer that has at least one free amine function and that is loaded with a plurality of peptide. This reaction results in an initial Schiff base (imine) linkage, which can be stabilized by reduction to a secondary amine to form the final conjugate.

The Fc region is absent if the antibody used as the antibody component of the immunoconjugate is an antibody fragment. However, it is possible to introduce a carbohydrate moiety into the light chain variable region of a full length antibody or antibody fragment. See, for example, Leung *et al., J. Immunol. 154*: 5919 (1995); Hansen *et al.*, U.S. Patent No. 5,443,953 (1995), Leung *et al.*, U.S. patent No. 6,254,868, all of which are incorporated in their entirety by reference. The engineered carbohydrate moiety is used to attach the therapeutic or diagnostic agent.

10. Pharmaceutically Acceptable Excipients

The humanized, chimeric and human anti-CD20 mAbs to be delivered to a subject can consist of the MAb alone, immunoconjugate, fusion protein, or can comprise one or more pharmaceutically suitable excipients, one or more additional ingredients, or some combination of these.

The immunoconjugate or naked antibody of the present invention can be formulated according to known methods to prepare pharmaceutically useful compositions, whereby the immunoconjugate or naked antibody are combined in a mixture with a pharmaceutically suitable excipient. Sterile phosphate-buffered saline is one example of a pharmaceutically suitable excipient. Other suitable excipients are well-known to those in the art. See, for example, Ansel *et al.*, PHARMACEUTICAL DOSAGE FORMS AND DRUG DELIVERY SYSTEMS, 5th Edition (Lea & Febiger 1990), and Gennaro (ed.), REMINGTON'S PHARMACEUTICAL SCIENCES, 18th Edition (Mack Publishing Company 1990), and revised editions thereof.

The immunoconjugate or naked antibody of the present invention can be formulated for intravenous administration via, for example, bolus injection or

continuous infusion. Preferably, the antibody of the present invention is infused over a period of less than about 4 hours, and more preferably, over a period of less than about 3 hours. For example, the first 25-50 mg could be infused within 30 minutes, preferably even 15 min, and the remainder infused over the next 2-3 hrs. Formulations for injection can be presented in unit dosage form, e.g., in ampules or in multi-dose containers, with an added preservative. The compositions can take such forms as suspensions, solutions or emulsions in oily or aqueous vehicles, and can contain formulatory agents such as suspending, stabilizing and/or dispersing agents. Alternatively, the active ingredient can be in powder form for constitution with a suitable vehicle, e.g., sterile pyrogen-free water, before use.

Additional pharmaceutical methods may be employed to control the duration of action of the therapeutic or diagnostic conjugate or naked antibody. Control release preparations can be prepared through the use of polymers to complex or adsorb the immunoconjugate or naked antibody. For example, biocompatible polymers include matrices of poly(ethylene-co-vinyl acetate) and matrices of a polyanhydride copolymer of a stearic acid dimer and sebacic acid. Sherwood *et al.*, *Bio/Technology* 10: 1446 (1992). The rate of release of an immunoconjugate or antibody from such a matrix depends upon the molecular weight of the immunoconjugate or antibody, the amount of immunoconjugate, antibody within the matrix, and the size of dispersed particles. Saltzman *et al.*, *Biophys. J.* 55: 163 (1989); Sherwood *et al.*, *supra*. Other solid dosage forms are described in Ansel *et al.*, PHARMACEUTICAL DOSAGE FORMS AND DRUG DELIVERY SYSTEMS, 5th Edition (Lea & Febiger 1990), and Gennaro (ed.), REMINGTON'S PHARMACEUTICAL SCIENCES, 18th Edition (Mack Publishing Company 1990), and revised editions thereof.

The immunoconjugate, antibody fusion proteins, or naked antibody may also be administered to a mammal subcutaneously or even by other parenteral routes. Moreover, the administration may be by continuous infusion or by single or multiple boluses. Preferably, the antibody of the present invention us infused over a period of less than about 4 hours, and more preferably, over a period of less than about 3 hours. This is preferably performed by infusing slowly at first. For example, a dose of 25 to 50 mg is infused within 15-30 minutes and the remainder of the dose is infused over a period of up to 2-3 hrs. In general, the dosage of an administered immunoconjugate,

fusion protein or naked antibody for humans will vary depending upon such factors as the patient's age, weight, height, sex, general medical condition and previous medical history. Typically, it is desirable to provide the recipient with a dosage of immunoconjugate, antibody fusion protein or naked antibody that is in the range of from about 1mg/kg to 20 mg/kg as a single intravenous infusion, although a lower or higher dosage also may be administered as circumstances dictate. Therefore, 1-20 mg/kg for a 70 kg patient, for example, is a dose of 70-1,400 mg, or 41-824 mg/m^2 for a 1.7-m patient. This dosage may be repeated as needed, for example, once per week for 4-10 weeks, preferably once per week for 8 weeks, and more preferably, once per week for 4 weeks. It may also be given less frequently, such as every other week for several months. More specifically, an antibody of the present invention, such as naked anti-CD20, may be administered as one dosage every 2 or 3 weeks, repeated for a total of at least 3 dosages. Also preferred, the antibodies of the present invention may be administered once per week for 4-8 weeks. In other words, if the dosage is lowered to approximately 200-300 mg/m^2 (which is 340 mg per dosage for a 1.7-m patient, or 4.9 mg/kg for a 70 kg patient), it may be administered once weekly for 4 to 8 weeks. Alternatively, the dosage schedule may be decreased, namely every 2 or 3 weeks for 2-3 months; for example, if the dosage is 300-500 mg/m^2 (i.e., 510-850 mg for a 1.7-m patient, or 7.3-12 mg/kg for a 70 kg patient). The dosing schedule can optionally be repeated at other intervals and dosage may be given through various parenteral routes, with appropriate adjustment of the dose and schedule.

For purposes of therapy, the immunoconjugate, fusion protein, or naked antibody is administered to a mammal in a therapeutically effective amount. A suitable subject for the present invention are usually a human, although a non-human animal subject is also contemplated. An antibody preparation is said to be administered in a "therapeutically effective amount" if the amount administered is physiologically significant. An agent is physiologically significant if its presence results in a detectable change in the physiology of a recipient mammal. In particular, an antibody preparation of the present invention is physiologically significant if its presence invokes an antitumor response or mitigates the signs and symptoms of an autoimmune disease state. A physiologically significant effect could also be the evocation of a humoral and/or cellular immune response in the recipient mammal.

11. Methods of Treatment

The present invention contemplates the use of naked anti-CD20 antibodies of the present invention as the primary composition for treatment of B cell disorders and other diseases. In particular, the compositions described herein are particularly useful for treatment of various autoimmune as well as indolent forms of B-cell lymphomas, aggressive forms of B-cell lymphomas, chronic lymphatic leukemias, acute lymphatic leukemias, and Waldenström's macroglobulinemia. For example, the humanized anti-CD20 antibody components and immunoconjugates can be used to treat both indolent and aggressive forms of non-Hodgkin's lymphoma.

The compositions for treatment contain at least one humanized, chimeric or human monoclonal anti-CD20 antibody alone or in combination with other antibodies, such as other humanized, chimeric, or human antibodies, therapeutic agents or immunomodulators. In particular, combination therapy with a fully human antibody is also contemplated and is produced by the methods as set forth above.

Naked or conjugated antibodies to the same or different epitope or antigen may be also be combined with one or more of the antibodies of the present invention. For example, a humanized, chimeric or human naked anti-CD20 antibody may be combined with another naked humanized, naked chimeric or naked human anti-CD20, a humanized, chimeric or human naked anti-CD20 antibody may be combined with an anti-CD20 immunoconjugate, a naked anti-CD20 antibody may be combined with an anti-CD22 radioconjugate or an anti-CD22 naked antibody may be combined with a humanized, chimeric or human anti-CD20 antibody conjugated to an isotope, or one or more chemotherapeutic agents, cytokines, toxins or a combination thereof. A fusion protein of a humanized, chimeric or human CD20 antibody and a toxin or immunomodulator, or a fusion protein of at least two different B-cell antibodies (e.g., a CD20 and a CD22 MAb) may also be used in this invention. Many different antibody combinations, targeting at least two different antigens associated with B-cell disorders, as listed already above, may be constructed, either as naked antibodies or as partly naked and partly conjugated with a therapeutic agent or immunomodulator, or merely in combination with another therapeutic agents, such as a cytotoxic drug or with radiation.

As used herein, the term "immunomodulator" includes cytokines, stem cell growth factors, lymphotoxins, such as tumor necrosis factor (TNF), and

hematopoietic factors, such as interleukins (*e.g.*, interleukin-1 (IL-1), IL-2, IL-3, IL-6, IL-10, IL-12, IL-21 and IL-18), colony stimulating factors (*e.g.*, granulocyte-colony stimulating factor (G-CSF) and granulocyte macrophage-colony stimulating factor (GM-CSF)), interferons (*e.g.*, interferons-α, -β and -γ), the stem cell growth factor designated "S1 factor," erythropoietin and thrombopoietin. Examples of suitable immunomodulator moieties include IL-2, IL-6, IL-10, IL-12, IL-18, IL-21, interferon-γ, TNF-α, and the like. Alternatively, subjects can receive naked anti-CD20 antibodies and a separately administered cytokine, which can be administered before, concurrently or after administration of the naked anti-CD20 antibodies. As discussed *supra*, the anti-CD20 antibody may also be conjugated to the immunomodulator. The immunomodulator may also be conjugated to a hybrid antibody consisting of one or more antibodies binding to different antigens.

Multimodal therapies of the present invention further include immunotherapy with naked anti-CD20 antibodies supplemented with administration of anti-CD22, anti-CD19, anti-CD21, anti-CD74, anti-CD80, anti-CD23, anti-CD46 or HLA-DR (including the invariant chain) antibodies in the form of naked antibodies, fusion proteins, or as immunoconjugates. The naked anti-CD20 antibodies or fragments thereof may also be supplemented with naked antibodies against a MUC1 antigen that is expressed on certain B-cells. These antibodies include polyclonal, monoclonal, chimeric, human or humanized antibodies that recognize at least one epitope on these antigenic determinants. Anti-CD19 and anti-CD22 antibodies are known to those of skill in the art. See, for example, Ghetie *et al., Cancer Res. 48*:2610 (1988); Hekman *et al., Cancer Immunol. Immunother. 32*:364 (1991); Longo, *Curr. Opin. Oncol. 8*:353 (1996) and U.S. Patent Nos. 5,798,554 and 6,187,287, incorporated in their entirety by reference.

In another form of multimodal therapy, subjects receive naked anti-CD20 antibodies, and/or immunoconjugates, in conjunction with standard cancer chemotherapy. For example, "CVB" (1.5 g/m^2 cyclophosphamide, 200-400 mg/m^2 etoposide, and 150-200 mg/m^2 carmustine) is a regimen used to treat non-Hodgkin's lymphoma. Patti *et al., Eur. J. Haematol. 51*: 18 (1993). Other suitable combination chemotherapeutic regimens are well-known to those of skill in the art. See, for example, Freedman *et al.*, "Non-Hodgkin's Lymphomas," in CANCER MEDICINE, VOLUME 2, 3rd Edition, Holland *et al.* (eds.), pages 2028-2068 (Lea & Febiger

1993). As an illustration, first generation chemotherapeutic regimens for treatment of intermediate-grade non-Hodgkin's lymphoma (NHL) include C-MOPP (cyclophosphamide, vincristine, procarbazine and prednisone) and CHOP (cyclophosphamide, doxorubicin, vincristine, and prednisone). A useful second generation chemotherapeutic regimen is m-BACOD (methotrexate, bleomycin, doxorubicin, cyclophosphamide, vincristine, dexamethasone and leucovorin), while a suitable third generation regimen is MACOP-B (methotrexate, doxorubicin, cyclophosphamide, vincristine, prednisone, bleomycin and leucovorin). Additional useful drugs include phenyl butyrate and brostatin-1. In a preferred multimodal therapy, both chemotherapeutic drugs and cytokines are co-administered with an antibody, immunoconjugate or fusion protein according to the present invention. The cytokines, chemotherapeutic drugs and antibody or immunoconjugate can be administered in any order, or together.

In a preferred embodiment, NHL or the autoimmune disease is treated with 4 weekly infusions of the humanized anti-CD20 antibody at a does of 200-400 mg/m^2 weekly for 4 consecutive weeks (iv over 2-6 hours), repeated as needed over the next months/yrs. Preferably, the humanized anti-CD-20 antibody is administered at a dose of 200-300 mg/m^2 once every other week or every third week, for 4 to 8 injections. Also preferred, NHL is treated with 4 weekly infusions as above, or injections less frequently as above, but combined with epratuzumAb (anti-CD22 humanized antibody) on the same days, at a dose of 360 mg/m^2, given as iv infusion over 1 hour, either before, during or after the anti-CD20 monoclonal antibody infusion. Or, the antibodies used in combination therapy may also be infused in alternative sequences, such that they are alternated on different weeks, resulting in each being given every other week for a total injection sequence for each of 4 to 8 or more doses. These dosage schedules can then be repeated at different intervals, such as every 3-6 months, depending on the patient's clinical status and response to each therapy regimen. Still preferred, NHL is treated with 4 weekly infusions, or less frequent infusions, of the anti-CD20 antibody as above, combined with one or more injections of CD22 MAb radiolabeled with a therapeutic isotope such as yttrium-90 (at a total dose of Y-90 between 5 and 35 mCi/meter-square as one or more injections over a period of weeks or months). US Serial No. 09/590,284 (Goldenberg *et al.*) discloses

immunotherapy of autoimmune disorders using an anti-CD22 antibody, which is incorporated herein by reference in its entirety.

In addition, a therapeutic composition of the present invention can contain a mixture or hybrid molecules of monoclonal naked anti-CD20 antibodies directed to different, non-blocking CD20 epitopes. Accordingly, the present invention contemplates therapeutic compositions comprising a mixture of monoclonal anti-CD20 antibodies that bind at least two CD20 epitopes. Additionally, the therapeutic composition described herein may contain a mixture of anti-CD20 antibodies with varying CDR sequences.

Although naked anti-CD20 antibodies are the primary therapeutic compositions for treatment of B cell lymphoma and autoimmune diseases, the efficacy of such antibody therapy can be enhanced by supplementing the naked antibodies, with supplemental agents, such as immunomodulators, like interferons, including IFN[illegible], IFN[illegible] and IFNγ, interleukins including IL-1, IL-2, IL-6, IL-12, IL-15, IL-18, IL-21, and cytokines including G-CSF and GM-CSF. Accordingly, the CD20 antibodies can be combined not only with antibodies and cytokines, either as mixtures (given separately or in some predetermined dosing regiment) or as conjugates or fusion proteins to the anti-CD20 antibody, but also can be given as a combination with drugs. For example, the anti-CD20 antibody may be combined with CHOP as a 4-drug chemotherapy regimen. Additionally, a naked anti-CD20 antibody may be combined with a naked anti-CD22 antibodies and CHOP or fludarabine as a drug combination for NHL therapy. Immunotherapy of B-cell malignancies using an anti-CD22 antibody is described in US Patent No. 6,183,744 (Goldenberg *et al.*) and US Serial No. 09/307,816 (Goldenberg *et al.*), which are incorporated herein by reference in their entirety. The supplemental therapeutic compositions can be administered before, concurrently or after administration of the anti-CD20 antibodies.

As discussed *supra*, the antibodies of the present invention can be used for treating B cell lymphoma and leukemia, and other B cell diseases or disorders. For example, anti-CD20 antibodies can be used to treat B-cell related autoimmune diseases, including Class III autoimmune diseases such as immune-mediated thrombocytopenias, such as acute idiopathic thrombocytopenic purpura and chronic idiopathic thrombocytopenic purpura, dermatomyositis, Sjögren's syndrome, multiple sclerosis, Sydenham's chorea, myasthenia gravis, systemic lupus erythematosus,

lupus nephritis, rheumatic fever, rheumatoid arthritis, polyglandular syndromes, bullous pemphigoid, diabetes mellitus, Henoch-Schonlein purpura, post-streptococcal nephritis, erythema nodosum, Takayasu's arteritis, Addison's disease, rheumatoid arthritis, sarcoidosis, ulcerative colitis, erythema multiforme, IgA nephropathy, polyarteritis nodosa, ankylosing spondylitis, Goodpasture's syndrome, thromboangitis ubiterans, , primary biliary cirrhosis, Hashimoto's thyroiditis, thyrotoxicosis, scleroderma, chronic active hepatitis, polymyositis/dermatomyositis, polychondritis, pamphigus vulgaris, Wegener's granulomatosis, membranous nephropathy, amyotrophic lateral sclerosis, tabes dorsalis, giant cell arteritis/polymyalgia, pernicious anemia, rapidly progressive glomerulonephritis and fibrosing alveolitis.

Anti-CD20 antibodies may also induce apoptosis in cells expressing the CD20 antigen. Evidence of this induction is supported in the literature. For example, it was demonstrated that apoptosis could be induced using lymphoid cells that have Fc-receptors reactive with the IgG1-Fc of CD20 MAbs that crosslinked. See Shan *et al.*, *Cancer Immunol. Immunother.* 48(12):673-683 (2000). Further, it was reported that aggregates of a chimeric CD20 MAb, i.e., homopolymers, induced apoptosis. See Ghetie *et al.*, *Blood* 97(5): 1392-1398 (2000) and Ghetie *et al.*, *Proc. Natl. Acad. Sci USA* 94(14): 7509-7514 (1997).

Antibodies specific to the CD20 surface antigen of B cells can be injected into a mammalian subject, which then bind to the CD20 cell surface antigen of both normal and malignant B cells. A mammalian subject includes humans and domestic animals, including pets, such as dogs and cats. The anti-CD20 mAbs of the present invention, i.e., humanized, chimeric, human, caninized and felinized, and even murine anti-CD20 mAbs, can be used to treat the non-human mammalian subjects when there is a species crossreactivity for the CD20 antigen. See Examples 10 and 11, below. The murine mAbs, which are immunogenic in humans, are usually less immunogenic in non-human mammalian subjects. The anti-CD20 antibody bound to the CD20 surface antigen leads to the destruction and depletion of neoplastic B cells. Because both normal and malignant B cells express the CD20 antigen, the anti-CD20 antibody will result in B cell death. However, only normal B cells will repopulate and the malignant B cells will be eradicated or significantly reduced. Additionally, chemical agents or radioactive labels having the potential to destroy the tumor can be

conjugated to the anti-CD20 antibody such that the agent is specifically targeted to the neoplastic B cells.

12. Expression Vectors

The DNA sequence encoding a humanized, chimeric or human anti-CD20 MAb can be recombinantly engineered into a variety of known host vectors that provide for replication of the nucleic acid. These vectors can be designed, using known methods, to contain the elements necessary for directing transcription, translation, or both, of the nucleic acid in a cell to which it is delivered. Known methodology can be used to generate expression constructs the have a protein-coding sequence operably linked with appropriate transcriptional/translational control signals. These methods include in vitro recombinant DNA techniques and synthetic techniques. For example, see Sambrook *et al.*, 1989, MOLECULAR CLONING: A LABORATORY MANUAL, Cold Spring Harbor Laboratory (New York); Ausubel *et al.*, 1997, CURRENT PROTOCOLS IN MOLECULAR BIOLOGY, John Wiley & Sons (New York). Also provided for in this invention is the delivery of a polynucleotide not associated with a vector.

Vectors suitable for use in the instant invention can be viral or non-viral. Particular examples of viral vectors include adenovirus, AAV, herpes simplex virus, lentivirus, and retrovirus vectors. An example of a non-viral vector is a plasmid. In a preferred embodiment, the vector is a plasmid.

An expression vector, as described herein, is a polynucleotide comprising a gene that is expressed in a host cell. Typically, gene expression is placed under the control of certain regulatory elements, including constitutive or inducible promoters, tissue-specific regulatory elements, and enhancers. Such a gene is said to be "operably linked to" the regulatory elements.

Preferably, the expression vector of the instant invention comprises the DNA sequence encoding a humanized, chimeric or human anti-CD20 MAb, which includes both the heavy and the light chain variable and constant regions. However, two expression vectors may be used, with one comprising the heavy chain variable and constant regions and the other comprising the light chain variable and constant regions. Still preferred, the expression vector further comprises a promoter. Because any strong promoter can be used, a DNA sequence encoding a secretion signal peptide, a genomic

sequence encoding a human IgG1 heavy chain constant region, an Ig enhancer element and at least one DNA sequence encoding a selection marker.

Also contemplated herein is a method for expressing a humanized anti-CD20 MAb, comprising (i) linearizing at least one expression vector comprising a DNA sequence encoding a humanized, chimeric, or human anti-CD20 MAb, (ii) transfecting mammalian cells with at least one of said linearized vector, (iii) selecting transfected cells which express a marker gene, and (iv) identifying the cells secreting the humanized anti-CD20 MAb from the transfected cells.

13. Methods of Making Anti-CD20 Antibodies

In general, the Vκ (variable light chain) and V_H (variable heavy chain) sequences for an anti-CD20 MAb can be obtained by a variety of molecular cloning procedures, such as RT-PCR, 5'-RACE, and cDNA library screening. Specifically, the V genes of an anti-CD20 MAb can be cloned by PCR amplification from a cell that expresses a murine or chimeric anti-CD20 MAb, sequenced. To confirm their authenticity, the cloned V_L and V_H genes can be expressed in cell culture as a chimeric Ab as described by Orlandi *et al.*, (*Proc. Natl. Acad. Sci.*, USA, 86: 3833 (1989)) which is incorporated by reference. Based on the V gene sequences, a humanized anti-CD20 MAb can then be designed and constructed as described by Leung et al. (*Mol. Immunol.*, 32: 1413 (1995)), which is incorporated by reference. cDNA can be prepared from any known hybridoma line or transfected cell line producing a murine or chimeric anti-CD20 MAb by general molecular cloning techniques (Sambrook et al., Molecular Cloning, A laboratory manual, 2nd Ed (1989)). The Vκ sequence for the MAb may be amplified using the primers VK1BACK and VK1FOR (Orlandi *et al.*, 1989) or the extended primer set described by Leung et al. (*BioTechniques*, 15: 286 (1993)), which is incorporated by reference, while V_H sequences can be amplified using the primer pair VH1BACK/VH1FOR (Orlandi *et al.*, 1989 above), or the primers annealing to the constant region of murine IgG described by Leung et al. (Hybridoma, 13:469 (1994)), which is incorporated by reference. The PCR reaction mixtures containing 10 μl of the first strand cDNA product, 10 μl of 10X PCR buffer [500 mM KCl, 100 mM Tris-HCl (pH 8.3), 15 mM $MgCl_2$, and 0.01% (w/v) gelatin] (Perkin Elmer Cetus, Norwalk, CT), 250 μM of each dNTP, 200 nM of the primers, and 5 units of Taq DNA polymerase (Perkin Elmer Cetus) can be subjected to 30 cycles of PCR. Each PCR cycle preferably

consists of denaturation at 94°C for 1 min, annealing at 50°C for 1.5 min, and polymerization at 72°C for 1.5 min. Amplified Vκ and VH fragments can be purified on 2% agarose (BioRad, Richmond, CA). Similarly, the humanized V genes can be constructed by a combination of long oligonucleotide template syntheses and PCR amplification as described by Leung et al. (*Mol. Immunol.*, 32: 1413 (1995)). See Example 3 for a method for the synthesis of an oligo A and an oligo B on an automated RNA/DNA synthesizer (Applied Biosystems, foster City, CA) for use in constructing humanized V genes.

PCR products for Vκ can be subcloned into a staging vector, such as a pBR327-based staging vector, VKpBR, that contains an Ig promoter, a signal peptide sequence and convenient restriction sites to facilitate in-frame ligation of the Vκ PCR products. PCR products for V_H can be subcloned into a similar staging vector, such as the pBluescript-based VHpBS. Individual clones containing the respective PCR products may be sequenced by, for example, the method of Sanger *et al.* (*Proc. Natl. Acad. Sci.*, USA, 74: 5463 (1977)), which is incorporated by reference.

The DNA sequences described herein are to be taken as including all alleles, mutants and variants thereof, whether occurring naturally or induced.

The expression cassettes containing the Vκ and VH, together with the promoter and signal peptide sequences can be excised from VKpBR and VHpBS, respectively, by double restriction digestion as HindIII-BamHI fragments. The Vκ and VH expression cassettes can then be ligated into appropriate expression vectors, such as pKh and pG1g, respectively (Leung et al., Hybridoma, 13:469 (1994)). The expression vectors can be co-transfected into an appropriate cell, e.g., myeloma Sp2/0-Ag14 (ATCC, VA), colonies selected for hygromycin resistance, and supernatant fluids monitored for production of a chimeric or humanized anti-CD20 MAb by, for example, an ELISA assay, as described below. Alternately, the Vκ and VH expression cassettes can be assembled in the modified staging vectors, VKpBR2 and VHpBS2, excised as XbaI/BamHI and XhoI/BamHI fragments, respectively, and subcloned into a single expression vector, such as pdHL2, as described by Gilles *et al.* (*J. Immunol. Methods* 125:191 (1989) and also shown in Losman et al., *Cancer*, 80:2660 (1997)) for the expression in Sp2/0-Ag14 cells. Another vector that is useful in the present invention is the GS vector, as described in Barnes *et al.*, *Cytotechnology* 32:109-123 (2000), which is preferably expressed in the NS0 cell line and CHO cells. Other appropriate mammalian

expression systems are described in Werner *et al.*, Arzneim.-Forsch./Drug Res. 48(II), Nr. 8, 870-880 (1998).

Co-transfection and assay for antibody secreting clones by ELISA, can be carried out as follows. About 10 μg of VKpKh (light chain expression vector) and 20 μg of VHpG1g (heavy chain expression vector) can be used for the transfection of 5 X 10^6 SP2/0 myeloma cells by electroporation (BioRad, Richmond, CA) according to Co *et al.*, *J. Immunol.*, 148: 1149 (1992) which is incorporated by reference. Following transfection, cells may be grown in 96-well microtiter plates in complete HSFM medium (Life Technologies, Inc., Grand Island, NY) at 37°C, 5%CO_2. The selection process can be initiated after two days by the addition of hygromycin selection medium (Calbiochem, San Diego, CA) at a final concentration of 500 units/ml of hygromycin. Colonies typically emerge 2-3 weeks post-electroporation. The cultures can then be expanded for further analysis.

Transfectoma clones that are positive for the secretion of chimeric or humanized heavy chain can be identified by ELISA assay. Briefly, supernatant samples (~100 μl) from transfectoma cultures are added in triplicate to ELISA microtiter plates precoated with goat anti-human (GAH)-IgG, F(ab')$_2$ fragment-specific antibody (Jackson ImmunoResearch, West Grove, PA). Plates are incubated for 1 h at room temperature. Unbound proteins are removed by washing three times with wash buffer (PBS containing 0.05% polysorbate 20). Horseradish peroxidase (HRP) conjugated GAH-IgG, Fc fragment-specific antibodies (Jackson ImmunoResearch) are added to the wells, (100 μl of antibody stock diluted x 10^4, supplemented with the unconjugated antibody to a final concentration of 1.0 μg/ml). Following an incubation of 1 h, the plates are washed, typically three times. A reaction solution, [100 μl, containing 167 μg of orthophenylene-diamine (OPD) (Sigma, St. Louis, MO), 0.025% hydrogen peroxide in PBS], is added to the wells. Color is allowed to develop in the dark for 30 minutes. The reaction is stopped by the addition of 50 μl of 4 N HCl solution into each well before measuring absorbance at 490 nm in an automated ELISA reader (Bio-Tek instruments, Winooski, VT). Bound chimeric antibodies are than determined relative to an irrelevant chimeric antibody standard (obtainable from Scotgen, Ltd., Edinburg, Scotland).

Antibodies can be isolated from cell culture media as follows. Transfectoma cultures are adapted to serum-free medium. For production of chimeric antibody, cells are grown as a 500 ml culture in roller bottles using HSFM. Cultures are centrifuged

and the supernatant filtered through a 0.2 μ membrane. The filtered medium is passed through a protein A column (1 x 3 cm) at a flow rate of 1 ml/min. The resin is then washed with about 10 column volumes of PBS and protein A-bound antibody is eluted from the column with 0.1 M glycine buffer (pH 3.5) containing 10 mM EDTA. Fractions of 1.0 ml are collected in tubes containing 10 μl of 3 M Tris (pH 8.6), and protein concentrations determined from the absorbance at 280/260 nm. Peak fractions are pooled, dialyzed against PBS, and the antibody concentrated, for example, with the Centricon 30 (Amicon, Beverly, MA). The antibody concentration is determined by ELISA, as before, and its concentration adjusted to about 1 mg/ml using PBS. Sodium azide, 0.01% (w/v), is conveniently added to the sample as preservative.

The following are the nucleotide sequences of the primers used to prepare the anti-CD20 antibodies:

hA20VKA

5'-CATCTCTGAG CGCATCTGTT GGAGATAGGG TCACTATGAC
TTGTAGGGCC AGCTCAAGTG TAAGTTACAT CCACTGGTTC
CAGCAGAAAC CAGGGAAAGC ACCTAAACCC TGGATTTATG-3'

hA20VKB

5'-GGTGTCCCTG TCCGATTCTC TGGCAGCGGA TCTGGGACAG
ATTACACTTT CACCATCAGC TCTCTTCAAC CAGAAGACAT
TGCAACATAT TATTGTCAGC AGTGGACTAG TAACCCACCC
ACGTTCGGTG-3'

hA20VKA-Backward

5'-CAGCTGACCC AGTCTCCATC ATCTCTGAGC GCATCTGTTG-3'

hA20VKA-Forward

5'-AGGTTCGAAG TGGCATAAAT CCAGGGTTTA GGTGCT-3'

hA20VKB Backward

5'-CACTTCGAAC CTGGCTTCTG GTGTCCCTGT CCGATTCTC-3'

hA20VKB Forward

5'-ACGTTAGATC TCCAGCTTGG TCCCTCCACC GAACGTGGGT GGGTTA-3'

hA20VHA

5'-CTGAAGTCAA GAAACCTGGG TCATCGGTGA AGGTCTCCTG CAAGGCTTCT GGCTACACCT TTACTAGTTA CAATATGCAC TGGGTCAAGC AGGCACCTGG ACAGGGTCTG GAATGGATTG G-3'

hA20VHB

5'-ATCAGAAGTT CAAGGGTAAA GCCACACTGA CTGCCGACGA ATCCACCAAT ACAGCCTACA TGGAGCTGAG CAGCCTGAGG TCTGAGGACA CGGCATTTTA TTACTGTGCA AGATCGACTT ACTACGGCGG TGACTGGTAC TTCGATGTCT G-3'

hA20VHA Backward

5'-CAGCTGCAGC AATCAGGGGC TGAAGTCAAG AAACCTGGG-3'

hA20VHA Forward

5'-TTCCGGGATA AATAGCTCCA ATCCATTCCA GACCCTG-3'

hA20VHB Backward

5'-ATCCCGGAAA TGGTGATACT TCCTACAATC AGAAGTTCAA GGGTAAAGCC A-3'

hA20VHB Forward

5'-GGAGACGGTG ACCGTGGTGC CTTGGCCCCA GACATCGAAG TACCAG-3'

hA20VH2A

5'-CTGAAGTCAA GAAACCTGGG TCATCAGTGA AGGTCTCCTG CAAGGCTTCT GGCTACACCT TTAGTAGTTA CAATATGCAC TGGGTCAGAC AGGCACCTGG ACAGGGTCTG GAATGGATGG G-3'

hA20VH2B

5'-ATCAGAAGTT CAAGGGTAGA GCCACAATAA CTGCCGACGA ATCCACCAAT ACAGCCTACA TGGAGCTGAG CAGCCTGAGG TCTGAGGACA CGGCATTTTA TTTTTGTGCA AGATCGACTT ACTACGGCGG TGACTGGTAC TTCGATGTCT G-3'

hA20VH2A Forward

5'-TTCCGGGATA AATAGCTCCC ATCCATTCCA GACCCTG-3'

hA20VH2B Backward

5'-ATCCCGGAAA TGGTGATACT TCCTACAATC AGAAGTTCAA GGGTAGAGCC A-3'

The invention is further described by reference to the following examples, which are provided for illustration only. The invention is not limited to the examples but rather includes all variations that are evident from the teachings provided herein.

EXAMPLES

Example 1. Construction of a humanized anti-CD20 antibody

The V_H and Vκ genes of A20, an anti-CD20 antibody, was obtained by RT-PCR using the primer pairs VH1BACK/ VH1FOR and VK1BACK/ VK1FOR, respectively Orlandi *et al.*, (*Proc. Natl. Acad. Sci.*, USA, 86: 3833 (1989)). Multiple independent clones were sequenced to eliminate possible errors resulting from the PCR reaction. The cloned murine V_H and Vκ sequences as the final PCR product were designated A20Vk (Figure 1A) and A20VH (Figure 1B), respectively. A chimeric A20 (cA20) antibody was constructed and expressed in Sp2/0 cell. The Vk and VH of sequences of cA20 are shown in Figure 2. The cA20 antibody bound to Raji cell and competed with radiolabeled A20 purified from the hybridoma cell culture supernatant (Figure 3). This result confirmed the authenticity of the cloned V genes.

A single light chain and two heavy chain variable region sequences encoding the humanized anti-hCD20 (hA20) antibody were designed and constructed. Human REI framework sequences were used for Vκ (Figure 1A), and a combination of EU and NEWM framework sequences were used for V_H (Figure 1B). There are a number

of amino acid changes in each chain outside of the CDR regions when compared to the starting human antibody frameworks. The heavy chain of hA20, hA20V_H1, contains nine changes, while hA20V_H2 contains three changes from the human EU frameworks (Figure 4A). hA20V_H2 is preferred because it contains more amino acids from the human antibody framework region than hA20V_H1. The light chain of hA20, hA20Vκ, contains seven amino acid changes from the REI framework (Figure 4B).

Example 2. Method of hA20 antibody construction

Each variable chain was constructed in two parts, a 5'- and 3'-half, designated as "A" and "B" respectively. Each half was produced by PCR amplification of a single strand synthetic oligonucleotide template with two short flanking primers, using Taq polymerase. The amplified fragments were first cloned into the pCR4 TA cloning vector from Invitrogen (Carlsbad, CA) and subjected to DNA sequencing. The templates and primer pairs are listed as follows:

Template	Primers
VKA	VkA-Backward/VkA-Forward
VKB	VkB-Backward/VkB-Forward
VH1A	VHA-Backward/VH1A-Forward
VH1B	VH1B-Backward/VHB-Forward
VH2A	VHA-Backward/VH2A-Forward
VH2B	VH2B-Backward/VHB-Forward

Light chain

For constructing the full-length DNA of the humanized Vκ sequence, oligo hA20VKA (120 mer) and hA20VKB (130 mer) were synthesized on an automated RNA/DNA synthesizer (Applied Biosystems). hA20VKA and B represent the nt 26-145 and 166-195, respectively, of the hA20 Vκ. (See Fig. 5A) Oligo hA20VKA and B were cleaved from the support and deprotected by treatment with concentrated ammonium hydroxide. After samples were vacuum-tried and resuspended in 100 μl of water, incomplete oligomers (less than 100-mer) were removed by centrifugation through a ChormaSpin-100 column (Clontech, Palo Alto, CA). All flanking primers were prepared similarly, except ChromaSpin-30 columns were used to remove synthesis by-products. 1 μl of ChromaSpin column purified hA20VKA was PCR amplified in a reaction volume of 100 μl containing 10 μl of 10X PCR buffer [500 mM

KCl, 100 mM Tris-HCl (pH 8.3), 15 mM $MgCl_2$, and 0.01% (w/v) gelatin] (Perkin Elmer Cetus, Norwalk, CT), 250 μM of each dNTP, 200 nM of VkA-Backward and VkA-Forward, and 5 units of Taq DNA polymerase (Perkin Elmer Cetus). This reaction mixture was subjected to 30 cycles of PCR reaction consisting of denaturation at 94°C for 1 min, annealing at 50 °C for 1.5 min, and polymerization at 72 °C for 1.5 min. hA20VKB was PCR-amplified by the primer pair VkB-Backward and VkB-Forward under similar condition. The amplified VKA and VKA fragments were purified on 2% agarose (BioRad, Richmond, CA). Unique restriction sites were designed at the ends of each fragment to facilitate joining through DNA ligation. The amplified VKA fragment contained a PvuII restriction site, CAGCTG, at its 5'-end and a BstBI restriction site, TTCGAA, at the 3'-end. The amplified VKB fragment contained a BstBI restriction site at its 5'-end and a BglII restriction site, AGATCT, at the 3'-end. Assembly of the full-length Vκ chain was accomplished by restriction enzyme digestion of each fragment with the appropriate 5'- and 3'-enzymes and ligation into the VKpBR2 vector previously digested with PvuII and BclI (BclI digested end is compatible with that of BglII). The resulting ligated product contains the A fragment ligated to the PvuII site, the B fragment ligated to the BclI site, and the A and B fragments joined together at the BstBI site (Figure 5A). VKpBR2 is a modified staging vector of VKpBR (Leung et al., Hybridoma, 13:469 (1994)), into which a XbaI restriction site was introduced at 14 bases upstream of the translation initiation codon. Upon confirmation of a correct open reading frame by DNA sequencing, the intact chain was removed from VKpBR2 as a XbaI to BamHI fragment and ligated into the pdHL2 expression vector. The vector containing only Vκ sequence was designated as hA20VκpdHL2. pdHL2 contains the expression cassettes for both human IgG1 C1, C2, C3, and hinge regions (Fig. 7A) and the human kappa chain Ck (Fig. 7B) under the control of IgH enhancer and MT_I promoter, as well as a mouse *dhfr* gene, controlled by a weak SV40 promotor, as a marker for selection of transfectants and co-amplification of the trans-genes (Gillies et al., *J. Immunol. Methods* 125:191 (1989); Losman et al., *Cancer* 80:2660 (1997)). By replacing the Vκ and VH segments of pdHL2, different chimeric or humanized Abs can be expressed.

Heavy chain

For the construction of hA20VH1, oligo VH1A (121 mer) and VH1B (151 mer), representing the nt 23-143 and 179-329, respectively, (See Fig. 5B) were synthesized as described above. Similarly, for hA20VH2, oligo VH2A and VH2B were prepared. These oligos were PCR-amplified by their respective primer pairs as listed in Example 2. The same construction method as done for Vκ was carried out for both types of V_H, with the following modifications: the 5'-end restriction site of the A fragments was PstI (CTGCAG) and the 3'-end restriction site of B fragments was BstEII (GGTCACC). These fragments were joined together upon ligation into the VHpBS2 vector at a common NciI site (CCCGG), resulting in full-length V_H sequences (Figure 5B and 5C) and confirmed by DNA sequencing. VHpBS2 is a modified staging vector of VHpBS (Leung et al., Hybridoma, 13:469 (1994)), into which a XhoI restriction site was introduced at 16 bases upstream of the translation initiation codon. The assembled V_H genes were subcloned as XhoI-BamHI restriction fragments into the expression vector containing the Vκ sequence, hA20VκpdHL2. Since the heavy chain region of pdHL2 lacks a BamHI restriction site, this ligation required use of the HNB linker to provide a bridge between the BamHI site of the variable chain and the HindIII site present in the pdHL2 vector. The resulting expression vectors were designated as hA20-1pdHL2 and hA20-2pdHL2.

HNB linker 5'-AGCTTGCGGCCGC-3'
3'-ACGCCGGCGCTAG-5'

Example 3. Transfection and Expression of hA20 Antibodies

Approximately 30 μg of the expression vectors for hA20 were linearized by digestion with SalI and transfected into Sp2/0-Ag14 cells by electroporation (450V and 25 μF). The transfected cells were plated into 96-well plates for 2 days and then selected for drug-resistance by adding MTX into the medium at a final concentration of 0.025 μM. MTX-resistant colonies emerged in the wells 2-3 weeks. Supernatants from colonies surviving selection were screened for human Ab secretion by ELISA assay. Briefly, 100 μl supernatants were added into the wells of a microtiter plate precoated with GAH-IgG, $F(ab')_2$ fragment-specific Ab and incubated for 1 h at room temperature. Unbound proteins were removed by washing three times with wash buffer (PBS containing 0.05% polysorbate 20). HRP-conjugated GAH-IgG, Fc fragment-

specific Ab was added to the wells. Following an incubation of 1 h, the plate was washed. The bound HRP-conjugated Ab was revealed by reading A490nm after the addition of a substrate solution containing 4 mM OPD and 0.04% H_2O_2. Positive cell clones were expanded and hA20-1 and hA20-2 were purified from cell culture supernatant by affinity chromatography on a Protein A column.

Example 4. Binding Activity of Anti-CD20 Antibodies

A competition cell-binding assay was carried out to assess the immunoreactivity of hA20 relative to the parent cA20 and the anti-CD20 Ab c2B8. A constant amount of ^{125}I-labeled murine A20 or c2B8 (100,000 cpm, ~10 µCi/µg) was incubated with Raji cell in the presence of varying concentrations (0.2-700 nM) of hA20-1, -2, murine A20, cA20, or c2B8 at 4°C for 1-2 h. Unbound Abs were removed by washing the cells in PBS. The radioactivity associated with cells was determined after washing. As shown in Figure 6, both humanized A20 mAbs, hA20-1 and hA20-2, exhibited comparable binding activities as A20, the murine anti-CD20 MAb, cA20, and c2B8, a chimeric anti-CD20 MAb, when competing with binding of ^{125}I-A20 or ^{125}I-c2B8 to Raji cells.

By direct binding of radiolabeled Mabs to Raji cells and Scatchard plot anlaysis, the dissociation constants were measured to be 2.9 and 4.2 nm for cA20 and hA20, respectively, in comparison to 3.9 nM for C2B8. In vitro crosslinking experiments, using a goat anti- human IgG, Fc fragment specific antibody to complex with the antibodies showed similar killing of Raji NHL cells between cA20 and hA20, as well as C2B8.

Example 5. Treatment of a Patient with Relapsed Intermediate-Grade Non-Hodgkin's Lymphoma

A patient with intermediate grade non-Hodgkin's lymphoma has failed prior aggressive chemotherapy, consisting of CHOP x 6, which led to a complete remission for four months, another course of CHOP x 6, resulting in progression, D-MOPP x 2, resulting in stable disease for three months, and CVB with peripheral stem cell transplantation, which led to a partial remission for five months. The patient presents with recurrent lymphoma in a neck lymph node, measurable by computerized tomography and palpation.

The patient is infused within 3 hrs with 450 mg of humanized CD20 monoclonal antibody A20 on days 0, 14, 28, and 42 with no serious adverse effects noted either during or immediately after the infusions. Eight weeks later, palpation of the neck node enlargement shows a measurable decrease of about 50%. Follow-up measurements made at twenty weeks post therapy show no evidence of the disease in the neck, and nowhere else, as confirmed by computed tomography studies of the body. Since new disease is not detected elsewhere, the patient is considered to be in complete remission. Follow-up studies every 10-12 weeks confirms a complete remission for at least ten months post therapy.

Example 6. Treatment of a patient with chronic idiopathic thrombocytopenia purpura

A 45-year-old female with chronic idiopathic thrombocytopenia purpura has been treated with prednisone, gamma globulins, and high dose dexamethasone, but the disease progresses. She undergoes splenectomy, which fails to stabilize the disease. Her platelet count falls to less than 30,000/microliter, and hemorrhagic events increase in frequency. The patient is then treated with the humanized CD20 A20 MAb, 500 mg intravenously on the first week, followed by a dose of 250 mg given once every other week for a total of 4 injections. Ten weeks after the last dose of A20 a marked increase in platelet number is observed, to 150,000/microliter, and the hemorrhagic events disappear. Five months after the last antibody infusion the disease is in remission.

Example 7. Treatment of a patient with progressive rheumatoid arthritis

A 70 year old female, with severe progressive rheumatoid arthritis of the finger joints, wrists, and elbows, has failed therapy with methotrexate, and obtains only minor relief when placed on Enbrel therapy. The patient is then treated with A20 humanized CD20 MAb, 300 mg intravenously each week, for a period of four weeks. After 3 months, a 40% improvement in measures of disease activity is observed, which is maintained for 5 months. The patient is again treated with A20, at the same dose and frequency. The patient continues to improve, and 6 months after the second A20 MAb therapy, a 60% improvement is observed. No human anti-A20 antibodies are observed at any time during, or after the A20 therapy. Although

normal B-cells are depleted from the blood, no infectious complications, or other drug-related severe toxicity is observed.

Example 8. Treatment of a patient with myasthenia gravis

A 65 year old male has failed all conventional therapy for myasthenia gravis, and is admitted to a neurological intensive therapy unit. The patient was stabilized by plasma exchange, and given intravenous immunoglobulin to reduce the titer of antiacetylcholine receptor antibody. The patient remained bedridden, and was then treated with A20 humanized CD20 MAb, 400 mg intravenously once every other week, for a period of ten weeks. One week after the last dose of A20, no blood B-cells were detectable, and a significant drop in the titer of the anti-acetylcholine antibody was observed. Four months after the last A20 MAb dose the patient was mobile, and was released from the hospital.

Example 9. Treatment of a Dog with Aggressive Non-Hodgkin's B-cell Lymphoma in Lymph Nodes and Bone Marrow

A 65-pound, 7-year old male Golden Retriever is diagnosed with diffuse large cell aggressive lymphoma. The dog is placed on combination chemotherapy with vincristine, cyclophosphamide, prednisolone, and doxorubicin, with good response. However, the dog subsequently is characterized as having progressive lymphadenopathy, and seven months after this is found to have extensive lymphoma infiltration of bone marrow, extensive lymphoadenopathy of neck, chest, abdomen, pelvis, and hepatosplenomegaly.

The dog is given therapy with 1F5 chimeric monoclonal antibody. The dog is infused intravenously with 120 mg of 1F5 antibody, and the treatment is repeated weekly for 4 weeks following this initial treatment. Four months after the final dose of 1F5, a computerized tomography scan of the patient shows no evidence of lymphoma, and all signs and symptoms of the disease were not evident.

Example 10. Treatment of a Dog with Relapsed Intermediate-Grade Non-Hodgkin's Lymphoma

A 78-pound, 9-year old, German Shepherd dog with intermediate grade non-Hodgkin's lymphoma receives chemotherapy, which initially leads to a complete

remission for five months, followed by another course of chemotherapy which results in stable disease for six months. The dog then presents with recurrent lymphoma in the chest and in a neck lymph node, both measurable by computerized tomography and palpation, respectively.

The patient is infused with a ^{90}Y-labeled immunoconjugate of L243 (HLA-DR) monoclonal antibody weekly for two weeks, at a radiation dose of 8 mCi in 50 mg of antibody protein, in combination with the A20 humanized CD20 antibody at a dose of 100 mg per each weekly infusion. Three weeks later, palpation of the neck node enlargement shows a measurable decrease, while a repeat computerized tomography scan of the chest shows a marked reduction in tumor. Follow-up measurements made at ten weeks post therapy show evidence of the disease in the neck or the chest being reduced by a about 60 percent. Since new disease is not detected elsewhere, the patient is considered to be in partial remission. Follow-up studies every 10-12 weeks confirms a partial remission for at least 7 months post therapy.

Example 11. Treatment of a Cat with Relapsed Lymphoma

A 10-pound, 12-year-old, domestic short hair presents with enlargement of a single submandibular lymph node. After excision, there is recurrence of the lesion at 6 months. The lesion is again excised, but then reappears 6 months later. The cat is then given weekly treatments for 4 weeks with an ^{131}I-labeled immunoconjugate of anti-CD20 B1 monoclonal antibody, at a radiation dose of 15 mCi in 45 mg antibody protein. The treatment is repeated 3 months later. When examined 3 months after the last treatment, a marked decrease can be palpated. No recurrence of the disease is observed for over one year.

Example 12. Evalulation of chimeric and humanized anti-CD20 Mabs in human NHL cells in culture or xenografted in SCID mice

The properties of a chimeric (cA20) and humanized (hA20) CD20 antibody was assessed in NHL cell lines. The results demonstrate that cA20 and hA20 behave similarly to Rituximab, staining more than 99% of Raji, Ramos, RL, Daudi and Su-DHL-6 cells and reacting with approximately 5% of lymphocytes (expected % B-cells). In all B-cell lines, specific growth inhibition was seen with the Mabs, but the

level o f inhibition varied between the cell lines, with Su-DHL being the most sensitive. In the absence of cross-linking, murine anti-CD20, cA20, hA20 and rituximab all yielded between 77 and 90% inhibition. With cross-linking, inhibition of proliferataion ranged from 94-98%. Rituximab, cA20, and hA20 were also similar in their ability to induce apoptosis in Raji cells in the presence of a cross-linking second monoclonal antibody.

Also, SCID mice were injected intravenously with $2.5X10^6$ Raji cells on day 0. Injections of murine, chimeric and humanized anti-CD20 antibodies, and the cA20 $F(ab')_2$ fragment were initiated on day-1 with 100 ⊠g/injection of intact antibody, or 67 ⊠g/injection $F(ab')_2$ fragment, five times per week for two weeks, the twice weekly for three weeks. In one study, control mice died of disseminated disease with a median survivial time of 15 days post tumor innoculation, but median survival was extended to 38 days for cA20, 22.5 days for hA20, and 21 days for murine anti-CD20 treated mice (all statistically significant by log-rank analysis ($p< 0.005$)). In another study, control mice died of disseminated disease manifested with CNS paralysis with a median survival time of 16.5days post tumor innoculation, but median survival was extended to 105days for cA20, 70 days for hA20, and 98 days for rituximab treated mice (all statistically significant extensions by log-rank analysis ($p<0.0001$), Figure 11).

Example 13. Competitive cell surface binding assay.

Ag-binding specificity and affinity studies of humanized anti-CD20 Abs (cA20, hA20, and c1F5), purified by affinity chromatography on a Protein A column) were evaluated by a cell surface competitive binding assay with murine 2B8 and rituximab (IDEC Pharmaceuticals Corp., San Diego, CA) (Figure 8). Briefly, a constant amount (100,000 cpm, ~10 ìCi/ìg) of ^{125}I-labeled (A) m2B8 or (B) rituximab was incubated with Raji cells in the presence of varying concentrations (0.2-700 nM) of competing Abs (cA20, hA20, m2B8, c1F5, or rituximab) at 4°C for 1-2 h. Unbound Abs were removed by washing the cells with PBS. Radioactivity associated with the cells was determined after washing. Figure 8 (A) is a comparison of the binding activities of cA20 (square), hA20-1 (triangle) and hA20-1 (circle) with that of m2B8 (diamond); Figure 8 (B) Compares the binding activities of cA20 (square), c1F5 (triangle) and rituximab (diamond).

In another study, the binding activities of hA20 with other anti-CD20 Abs, rituximab and murine B1 were compared by a cell surface competitive binding assay (Figure 9). Briefly, a constant amount (100,000 cpm, ~10 ìCi/ìg) of ^{125}I-labeled rituximab was incubated with Raji cells in the presence of varying concentrations (0.2-700 nM) of competing Abs, hA20 (triangle), mB1 (Downward triangle) or rituximab (square) at 4°C for 1-2 h. Unbound Abs were removed by washing the cells with PBS. Radioactivity associated with the cells was determined after washing. The IC_{50} values for these three Abs were calculated to be 6.8, 34, and 5, respectively.

Example 14. Cytotoxic effect of crosslinked hA20 and other CD20 Abs on cultured lymphoma cells.

Raji cells were treated with various CD20 Abs in the presence of a crosslinker (an anti-human IgG, Fc fragment specific antibody) to complex the CD20 antibodies (Figure 10). A final concentration of 5 ìg/ml of hA20, cA20, rituximab, or a positive control Ab, hLL1, was incubated with Raji cells, with 20 ìg/ml of the crosslinker (red), without the crosslinker (orange), or with an anti-mouse IgG, Fc fragment specific antibody (blue) for 48 h. Total cell and viable cell populations were measured by (A) trypan blue staining and cell counting or (B) MTT assay (B). The data show a similar effect of hA20 and rituximab on Raji NHL cell survival, and that the cytotoxic effect is dependent on the specific crosslinking of the antibodies.

Example 15. *In vivo* therapy with hA20 and hLL2.

Raji cells wer administered i.v. to 60 SCID mice, at 2.5 x 10^6 cells/100 µl/mouse (Figure 12). MAbs were administered i.p. on days 1 to 11, followed by MAb injections twice per week, for approximately 3 weeks. The body weight of the animals was measured weekly until the study was terminated. The animals were examined daily for paralysis of the hind legs. When paralysis occured, the animals were sacrificed and necropsied for visual inspection of disseminated tumor nodules (specifically in lungs, kidneys, and ovaries). Control mice treated with a control humanized IgG1 Ab, hMN-14 (an anti-CEA antibody), died of disseminated disease manifested with CNS paralysis. The median survival time was 13 days post tumor i.v. inoculation. Median survival in the group treated with hA20 was extended to about 25 days. This value represents median survival increase of approximately 2 fold

for hA20. Although the group treated with hLL2 alone showed the same median survival time compared to the control mice, treatment with combination of hA20 and hLL2 increased the median survival time of the mice to approximately 30 days.

We Claim:

1. A humanized anti-CD20 (hCD20) monoclonal antibody or antigen-binding fragment thereof comprising the complementarity determining regions (CDRs) of at least one murine anti-CD20 MAb variable region and the framework regions (FRs) of at least one human MAb variable region, wherein said humanized anti-CD20 MAb or fragment thereof retains substantially the B-cell and B-cell lymphoma and leukemia cell targeting of said murine anti-CD20 MAb.

2. The humanized antibody or fragment thereof of claim 1, wherein said variable region comprises a light chain variable region.

3. The humanized antibody or fragment thereof of claim 1, wherein said variable region comprises a heavy chain variable region.

4. The humanized antibody or fragment thereof of claim 1, wherein said variable region comprises light and heavy chain variable regions.

5. The humanized antibody or fragment thereof of claim 4, further comprising light and heavy chain constant regions of at least one human antibody.

6. The humanized antibody or fragment thereof of claim 2, wherein said light chain variable region comprises CDR1 comprising an amino acid sequence selected from the group consisting of RASSSVSYIH, RASSSLSFMH and RASSSVSYMH; CDR2 comprising an amino acid sequence of ATSNLAS; and CDR3 comprising an amino acid sequence selected from the group consisting of QQWTSNPPT, HQWSSNPLT and QQSFSNPPT.

7. The humanized antibody or fragment thereof of claim 3, wherein said heavy chain variable region comprises CDR1 comprising an amino acid sequence of SYNMH; CDR2 comprising an amino acid sequence of AIYPGNGDTSYNQKFKG and CDR3 comprising an amino acid sequence selected from the group consisting of

STYYGGDWYFDV, STYYGGDWYFNV, SHYGSNYVDYFDV and VVYYSNSYWYFDV.

8. The humanized antibody or fragment thereof of claim 4, wherein said light chain variable region comprises CDR1 comprising an amino acid sequence selected from the group consisting of RASSSVSYIH, RASSSLSFMH and RASSSVSYMH; CDR2 comprising an amino acid sequence of ATSNLAS; and CDR3 comprising an amino acid sequence selected from the group consisting of QQWTSNPPT, HQWSSNPLT and QQSFSNPPT; and said heavy chain variable region comprises CDR1 comprising an amino acid sequence of SYNMH; CDR2 comprising an amino acid sequence of AIYPGNGDTSYNQKFKG and CDR3 comprising an amino acid sequence selected from the group consisting of STYYGGDWYFDV, STYYGGDWYFNV, SHYGSNYVDYFDV and VVYYSNSYWYFDV.

9. The humanized antibody or fragment thereof of claim 8, further comprising the FRs of the light and heavy chain constant regions of a human antibody.

10. The humanized antibody or fragment thereof of claim 8, wherein said CDR3 of the heavy chain variable region does not comprise STYYGGDWYFNV.

11. The humanized antibody or fragment thereof of claim 8, wherein said CDR1 of the light chain variable region does not comprise RASSSLSFMH when said CDR3 of the light chain variable region comprises HQWSSNPLT and said CDR3 of the heavy chain variable region comprises SHYGSNYVDYFDV.

12 The humanized antibody or fragment thereof of claim 8, wherein said CDR3 of the light chain variable region does not comprise HQWSSNPLT when said CDR1 of the light chain variable region comprises RASSSLSFMH and said CDR3 of the heavy chain variable region comprises SHYGSNYVDYFDV.

13. The humanized antibody or fragment thereof of claim 8, wherein said CDR3 of the heavy chain variable region does not comprise SHYGSNYVDYFDV when said

CDR1 of the light chain variable region comprises RASSSLSFMH and said CDR3 of the light chain variable region comprises HQWSSNPLT.

14. The humanized antibody or fragment thereof of claim 8, wherein said CDR1 of the light chain variable region does not comprise RASSSVSYMH when said CDR3 of the light chain variable region comprises QQSFSNPPT and said CDR3 of the heavy chain variable region comprises VVYYSNSYWYFDV.

15. The humanized antibody or fragment thereof of claim 8, wherein said CDR3 of the light chain variable region does not comprise QQSFSNPPT when CDR1 of the light chain variable region comprises RASSSVSYMH and said CDR3 of the heavy chain variable region comprises VVYYSNSYWYFDV.

16. The humanized antibody or fragment thereof of claim 8, wherein said CDR3 of the heavy chain variable region does not comprise VVYYSNSYWYFDV when said CDR1 of the light chain variable region comprises RASSSVSYMH and said CDR3 of the light chain variable region comprises QQSFSNPPT.

17. A humanized anti-CD20 (hCD20) monoclonal antibody (MAb) or fragment thereof comprising the complementarity-determining regions (CDRs) of at least one murine anti-CD20 MAb and the framework (FR) regions of the light and heavy chain variable regions of a human antibody, wherein said humanized anti-CD20 MAb or fragment thereof retains substantially the B-cell, and B-cell lymphoma cell and leukemia cell targeting of said murine anti-CD20 MAb, and wherein the CDRs of the light chain variable region of the murine anti-CD20 MAb comprises CDR1 comprising an amino acid sequence of RASSSVSYIH, CDR2 comprising an amino acid sequence of ATSNLAS and CDR3 comprising an amino acid sequence of QQWTSNPPT and the CDRs of the heavy chain variable region of murine anti-CD20 MAb comprises CDR1 comprising an amino acid sequence of SYNMH, CDR2 comprising an amino acid sequence of AIYPGNGDTSYNQKFKG and CDR3 comprising an amino acid sequence of STYYGGDWYFDV.

18. The humanized antibody or fragment thereof of claim 1, wherein said FRs of the light and heavy chain variable regions of said humanized antibody comprise at least one amino acid substituted from said corresponding FRs of said murine MAb.

19. The humanized antibody or fragment thereof of claim 18, wherein said amino acid from said murine MAb is at least one amino acid selected from the group consisting of amino acid residue 1, 5, 27, 30, 38, 48, 67, 68, 70, 95, 115 and 116 of the murine heavy chain variable region of Fig. 4A, hA20VH1 or hA20VH2 amino acid sequences.

20. The humanized antibody or fragment thereof of claim 19, wherein said murine amino acids are at least one amino acid selected from the group consisting of amino acid residue 4, 21, 35, 38, 45, 46, 59, 99, 104 and 106 of the murine light chain variable region Fig. 4B, hA20Vk sequence.

21. The humanized antibody or fragment thereof of claim 18, wherein said murine amino acids are at least one amino acid selected from the group consisting of amino acid residue 4, 21, 35, 38, 45, 46, 59, 99, 104 and 106 of the murine light chain variable region Fig. 4B, hA20Vk sequence.

22. A humanized antibody or fragment thereof comprising the hA20Vk of Figure 4B and the hA2VH1 of Figure 4A.

23. A humanized antibody or fragment thereof comprising the hA20Vk of Figure 4B and the hA2VH2 of Figure 4A.

24. The humanized MAb and fragments thereof of claim 1, wherein said fragments are selected from the group consisting of $F(ab')_2$, Fab', Fab, Fv and sFv.

25. A chimeric anti-CD20 (cCD20) monoclonal antibody, (MAb) or fragment thereof comprising the complementarity-determining regions (CDRs) of at least one murine anti-CD20 MAb variable region and the framework regions (FRs) of at least one murine anti-CD 20 MAb variable region, wherein said chimeric anti-CD20 MAb or fragment thereof retains substantially the B-cell, and B-cell lymphoma and leukemia cell

targeting of said murine anti-CD20 MAb, wherein the CDRs of the light chain variable region of the chimeric anti-CD20 MAb comprises CDR1 comprising an amino acid sequence selected from the group consisting of RASSSVSYIH, RASSSLSFMH and RASSSVSYMH; CDR2 comprising an amino acid sequence of ATSNLAS; and CDR3 comprising an amino acid sequence selected from the group consisting of QQWTSNPPT, HQWSSNPLT and QQSFSNPPT; and the CDRs of the heavy chain variable region of the chimeric anti-CD20 MAb comprises CDR1 comprising an amino acid sequence of SYNMH; CDR2 comprising an amino acid sequence of AIYPGNGDTSYNQKFKG and CDR3 comprising an amino acid sequence selected from the group consisting of STYYGGDWYFDV, STYYGGDWYFNV, SHYGSNYVDYFDV and VVYYSNSYWYFDV with the following provisos,

(a) wherein said CDR3 of the heavy chain variable region does not comprise STYYGGDWYFNV, when said CDR1 of the light chain variable region comprises amino acids RASSSVSYIH, CDR2 of the light chain variable region comprises amino acids ATSNLAS, CDR3 of the light chain variable region comprises amino acids QQWTSNPPT, CDR1 of the heavy chain variable region comprises amino acids SYNMH, and CDR2 of the light chain variable region comprises amino acids AIYPGNGDTSYNQKFKG;

(b) wherein said CDR3 of the heavy chain variable region does not comprise SHYGSNYVDYFDV, when said CDR1 of the light chain variable region comprises amino acids RASSSLSFMH, CDR2 of the light chain variable region comprises amino acids ATSNLAS, CDR3 of the light chain variable region comprises amino acids HQWSSNPLT, CDR1 of the heavy chain variable region comprises amino acids SYNMH, and CDR2 of the light chain variable region comprises amino acids AIYPGNGDTSYNQKFKG; and

(c) wherein said CDR3 of the heavy chain variable region does not comprise VVYYSNSYWYFDV, when said CDR1 of the light chain variable region comprises amino acids RASSSVSYMH, CDR2 of the light chain variable region comprises amino acids ATSNLAS, CDR3 of the light chain variable region comprises amino acids QQSFSNPPT, CDR1 of the heavy chain variable region comprises amino acids SYNMH, and CDR2 of the light chain variable region comprises amino acids AIYPGNGDTSYNQKFKG.

26. The chimeric antibody or fragment thereof of claim 25, further comprising light and heavy chain constant regions of at least one human antibody.

27. A chimeric anti-CD20 (cCD20) monoclonal antibody, (MAb) or fragment thereof comprising the complementarity-determining regions (CDRs) of a murine anti-CD20 MAb variable region, wherein said chimeric anti-CD20 MAb or fragment thereof retains substantially the B-cell, and B-cell lymphoma and leukemia cell targeting of said murine anti-CD20 MAb, wherein the CDRs of the light chain variable region of the chimeric anti-CD20 MAb comprises CDR1 comprising an amino acid sequence of RASSSVSYIH, CDR2 comprising an amino acid sequence of ATSNLAS, and CDR3 comprising an amino acid sequence of QQWTSNPPT, and the CDRs of the heavy chain variable region of the chimeric anti-CD20 MAb comprises CDR1 comprising an amino acid sequence of SYNMH, CDR2 comprising an amino acid sequence of AIYPGNGDTSYNQKFKG and CDR3 comprising an amino acid sequence of STYYGGDWYFDV.

28. The chimeric antibody or fragment thereof of claim 27, further comprising light and heavy chain constant regions of at least one human antibody.

29. A chimeric anti-CD20 (cCD20) monoclonal antibody (MAb) or fragment thereof comprising the light and heavy chain variable regions of murine anti-CD20 MAb, wherein said cCD20 MAb retains substantially the B-cell, and B-cell lymphoma and leukemia cell targeting and cell binding characteristics of said murine anti-CD20 MAb, wherein said cCD20 comprises the light chain variable region as set forth in Figure 4B designated as cA20Vk and the heavy chain variable region set forth in Figure 4A designated as cA20VH.

30. A human anti-CD20 (huCD20) monoclonal antibody (MAb) or fragment thereof comprising the light and heavy chain variable regions of a human antibody, wherein said huCD20 MAb retains substantially the B-cell, and B-cell lymphoma and leukemia cell targeting and cell binding characteristics of a murine anti-CD20 MAb, wherein the CDRs of the light chain variable region of the human anti-CD20 MAb comprises CDR1 comprising an amino acid sequence selected from the group consisting of

RASSSVSYIH, RASSSLSFMH and RASSSVSYMH; CDR2 comprising an amino acid sequence of ATSNLAS; and CDR3 comprising an amino acid sequence selected from the group consisting of QQWTSNPPT, HQWSSNPLT and QQSFSNPPT; and the CDRs of the heavy chain variable region of the human anti-CD20 MAb comprises CDR1 comprising an amino acid sequence of SYNMH; CDR2 comprising an amino acid sequence of AIYPGNGDTSYNQKFKG and CDR3 comprising an amino acid sequence selected from the group consisting of STYYGGDWYFDV, STYYGGDWYFNV, SHYGSNYVDYFDV and VVYYSNSYWYFDV.

31. The chimeric antibody or fragment thereof of claim 30, further comprising light and heavy chain constant regions of at least one human antibody.

32. An antibody fusion protein or fragment thereof comprising at least two mAbs or fragments thereof, wherein said mAbs are selected from said anti-CD20 mAbs of any one of claims 1-31.

33. An antibody fusion protein or fragment thereof comprising at least one first anti-CD20 MAb or fragment thereof of any one of claims 1-31 and at least one second MAb or fragment thereof, other than the antiCD20 MAb or fragment thereof of any one of claims 1-31.

34. An antibody fusion protein or fragment thereof of claim 33, wherein said second MAb is selected from the group consisting of mAbs reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an oncogene, an oncogene product, and a combination thereof.

35. A DNA sequence comprising a nucleic acid encoding a MAb or fragment thereof selected from the group consisting

(a) an anti-CD20 MAb or fragment thereof of any one of claims 1-31;

(b) an antibody fusion protein or fragment thereof comprising at least two of said anti-CD20 mAbs or fragments thereof;

(c) an antibody fusion protein or fragment thereof comprising at least one first MAb or fragment thereof comprising said anti-CD20 MAb or fragment thereof of any one of claims 1-31 and at least one second MAb or fragment thereof, other than the antiCD20 MAb or fragment thereof of any one of claims 1-31; and

(d) an antibody fusion protein or fragment thereof comprising at least one first MAb or fragment thereof comprising said anti-CD20 MAb or fragment thereof of any one of claims 1-31 and at least one second MAb or fragment thereof, other than the antiCD20 MAb or fragment thereof of any one of claims 1-31, wherein said second MAb is selected from the group consisting of mAbs reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PIGF, oncogenes, oncogene products, or a combination thereof and a combination thereof.

36. An expression vector comprising the DNA sequence of claim 35.

37. An expression vector of claim 36, wherein the vector is pdHL2 or GS.

38. An expression vector of claim 37, wherein the pdHL2 or GS vector, when used to express a chimeric, humanized or human IgG, codes for the heavy and light chain constant regions and hinge region of IgG1.

39. An expression vector of claim 38, wherein said heavy chain constant regions and hinge region shown in Fig. 7A and said light chain constant region is shown in Fig. 7B, wherein optionally at least one of the amino acids in the allotype positions is changed to that found in different IgG1 allotype, and wherein optionally amino acid 253 of the heavy chain of EU may be replaced with alanine.

40. A host cell comprising the DNA sequence of claim 35.

41. A host cell of claim 40, wherein said cell is a mammalian cell.

42. A host cell of claim 41, wherein said mammalian cell is a lymphocytic cell.

43. A host cell of claim 42, wherein said lymphocytic cell is a myeloma cell.

44. A host cell comprising the expression vector of claim 38.

45. A host cell of claim 44, wherein said cell is a mammalian cell.

46. A host cell of claim 45, wherein said mammalian cell is a lymphocytic cell.

47. A host cell of claim 46, wherein said lymphocytic cell is a myeloma cell.

48. A host cell comprising the DNA sequence of claim 39

49. A host cell of claim 48, wherein said cell is a mammalian cell.

50. A host cell of claim 49, wherein said mammalian cell is a lymphocytic cell.

51. A host cell of claim 50, wherein said lymphocytic cell is a myeloma cell.

52. A method for the expression of an anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof comprising:

(a) transfecting a mammalian cell with a DNA sequence of claim 35; and

(b) culturing said cell secreting said anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof.

53. A method for the expression of an anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof comprising:

(a) transfecting a mammalian cell with a DNA sequence of claim 38; and

(b) culturing said cell secreting said anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof.

54. A method for the expression of an anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof comprising:

(a) transfecting a mammalian cell with a DNA sequence of claim 39; and

(b) culturing said cell secreting said anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof.

55. A B-lymphoma and leukemia cell targeting diagnostic or therapeutic conjugate comprising an antibody component comprising an anti-CD20 MAb or fragment thereof or an antibody fusion protein or fragment thereof of any one of claims 1-34 that binds to said cell, wherein said antibody component is bound to at least one diagnostic or at least one therapeutic agent.

56. A diagnostic conjugate according to claim 55, wherein said diagnostic agent comprises at least one photoactive diagnostic agent.

57. A diagnostic conjugate of claim 56, wherein said diagnostic agent is a radioactive label with an energy between 60 and 4,000 keV.

58. A diagnostic conjugate of claim 57, wherein said radioactive label is a gamma-, beta- or a positron-emitting isotope.

59. A diagnostic conjugate of claim 58, wherein said radioactive label is selected from the group consisting of ^{125}I, ^{131}I, ^{123}I, ^{124}I, ^{86}Y, ^{186}Re, ^{188}Re, ^{62}Cu, ^{64}Cu, ^{111}In, ^{67}Ga, ^{68}Ga, ^{99m}Tc, ^{94m}Tc, ^{18}F, ^{11}C, ^{13}N, ^{15}O, and ^{76}Br.

60. A diagnostic conjugate of claim 55, wherein said diagnostic agent is a contrast agent.

61. A diagnostic conjugate of claim 60, wherein said contrast agent is a metal comprising manganese, iron or gadolinium.

62. A therapeutic conjugate of claim 55, wherein said antibody component is an antibody fusion protein or fragment thereof, wherein each of said mAbs or fragments thereof are bound to at least one therapeutic agent.

63. A therapeutic conjugate of claim 55 or 62, wherein said therapeutic agent is selected from the group consisting of a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, a cytotoxic agent, an oligonucleotide and a combination thereof.

64. A therapeutic conjugate of claim 63, wherein said cytotoxic agent is a drug or a toxin.

65. A therapeutic conjugate of claim 63, wherein said oligonucleotide is an antisense oligonucleotide.

66. A therapeutic conjugate of claim 64, wherein said drug possesses the pharmaceutical property selected from the group consisting of antimitotic, alkylating, antimetabolite, antiangiogenic, apoptotic, alkaloid, antikinase and antibiotic agents, taxanes, and combinations thereof.

67. A therapeutic conjugate of claim 64, wherein said drug is selected from the group consisting of nitrogen mustards, ethylenimine derivatives, alkyl sulfonates, nitrosoureas, triazenes, folic acid analogs, anthracyclines, taxanes, COX-2 inhibitors, pyrimidine analogs, purine analogs, antibiotics, enzymes, epipodophyllotoxins, platinum coordination complexes, vinca alkaloids, substituted ureas, methyl hydrazine derivatives, adrenocortical suppressants, antagonists, endostatin, taxols, camptothecins, doxorubicins and their analogs, and a combination thereof.

68. A therapeutic conjugate of claim 64, wherein said toxin is selected from the group consisting of ricin, abrin, alpha toxin, saporin, ribonuclease (RNase), DNase I, *Staphylococcal* enterotoxin-A, pokeweed antiviral protein, gelonin, diphtherin toxin, *Pseudomonas* exotoxin, and *Pseudomonas* endotoxin.

69. A therapeutic conjugate of claim 63, wherein said immunomodulator is selected from the group consisting of a cytokine, a stem cell growth factor, a lymphotoxin, a hematopoietic factor, a colony stimulating factor (CSF), an interferon (IFN), a stem cell growth factor, erythropoietin, thrombopoietin and a combination thereof.

70. A therapeutic conjugate of claim 69, wherein said lymphotoxin is tumor necrosis factor (TNF), said hematopoietic factor is an interleukin (IL), said colony stimulating factor is granulocyte-colony stimulating factor (G-CSF) or granulocyte macrophage-colony stimulating factor (GM-CSF)), said interferon is interferons-α, -β or -γ, and said stem cell growth factor is designated "S1 factor".

71. A therapeutic conjugate of claim 69, wherein said immunomodulator comprises IL-1, IL-2, IL-3, IL-6, IL-10, IL-12, IL-18, IL-21, interferon-γ, TNF-α or a combination thereof.

72. A therapeutic conjugate of claim 63, wherein said radioactive label has an energy between 60 and 700 keV.

73. A therapeutic conjugate of claim 72,wherein said radioactive label is selected from the group consisting of ^{225}Ac, , ^{67}Ga, ^{90}Y, ^{86} Y, ^{111}In, ^{131}I, ^{125}I, , ^{186}Re, ^{188}Re, ^{177}Lu, ^{64}Cu, ^{67}Cu, ^{212}Bi, ^{213}Bi, ^{211}At, ^{32}P, and combinations thereof.

74. A therapeutic conjugate of claim 63, wherein said photoactive therapeutic agent is a chromogen or dye.

75. A method of treating a B-cell lymphoma or leukemia or an autoimmune disease in a subject comprising administering to said subject a therapeutically effective amount of an anti-CD20 MAb or a fragment thereof of any one of claims 1-20, formulated in a pharmaceutically acceptable vehicle.

76. A method of claim 75, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of at least one humanized, chimeric, human or murine MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an

oncogene, an oncogene product, and a combination thereof, formulated in a pharmaceutically acceptable vehicle.

77. A method of claim 75, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of at least one therapeutic agent, formulated in a pharmaceutically acceptable vehicle.

78. A method of claim 77, wherein said therapeutic agent comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, an enzyme, an oligonucleotide, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

79. A method of claim 78, wherein said oligonucleotide is an antisense oligonucleotide.

80. A method of claim 76, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of at least one therapeutic agent, formulated in a pharmaceutically acceptable vehicle.

81. A method of claim 80, wherein said therapeutic agent comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, an oligonucleotide or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

82. A method of claim 81, wherein said oligonucleotide is an antisense oligonucleotide.

83. A method of claim of 75, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of a therapeutic conjugate comprising at least one MAb bound to at least one therapeutic agent, wherein said MAb comprises at least one humanized, chimeric, human or murine MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52,

CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an oncogene, an oncogene product, and a combination thereof formulated in a pharmaceutically acceptable vehicle.

84. A method of claim 83, wherein said therapeutic agent comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, an enzyme, an oligonucleotide, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

85. A method of claim 84, wherein said oligonucleotide is an antisense oligonucleotide.

86. A method of claim of 76, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of a therapeutic conjugate comprising at least one MAb bound to at least one therapeutic agent, wherein said MAb comprises at least one humanized, chimeric, human or murine MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an oncogene, an oncogene product, and a combination thereof formulated in a pharmaceutically acceptable vehicle.

87. A method of claim 86, wherein said therapeutic agent comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, an enzyme, an oligonucleotide, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

88. A method of claim 86, wherein said oligonucleotide is an antisense oligonucleotide.

89. A method of treating a B-cell lymphoma or leukemia or an autoimmune disease in a subject comprising administering to said subject a therapeutically effective amount of an antibody fusion protein or fragment thereof comprising at least two mAbs or

fragments thereof, wherein said mAbs are selected from said mAbs of any one of claims 1-31 or comprising at least one MAb or fragment thereof of any one of claims 1-31 and at least one MAb selected from the group consisting of mAbs reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an oncogene, an oncogene product, and a combination thereof formulated in a pharmaceutically acceptable vehicle.

90. A method of claim 89, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of at least one therapeutic agent, formulated in a pharmaceutically acceptable vehicle.

91. A method of claim 90, further comprising a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, an oligonucleotide or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

92. A method of claim 91, wherein said oligonucleotide is an antisense oligonucleotide.

93. A method of claim of 77, further comprising administering to said subject concurrently or sequentially a therapeutically effective amount of a therapeutic conjugate comprising at least one MAb bound to at least one therapeutic agent, wherein said MAb comprises at least one humanized, chimeric, human or murine MAb selected from the group consisting of a MAb reactive with CD4, CD5, CD8, CD14, CD15, CD19, CD20, CD21, CD22, CD23, CD25, CD33, CD37, CD38, CD40, CD40L, CD46, CD52, CD54, CD74, CD80, CD126, B7, MUC1, Ia, HM1.24, HLA-DR, tenascin, VEGF, PlGF, an oncogene, an oncogene product, and a combination thereof formulated in a pharmaceutically acceptable vehicle.

94. A method of claim 93, wherein said therapeutic agent comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, an enzyme, an oligonucleotide a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

95. A method of claim 94, wherein said oligonucleotide is an antisense oligonucleotide.

96. A method of treating a B-cell lymphoma or leukemia or an autoimmune disease in a subject comprising administering to said subject a therapeutically effective amount of a therapeutic conjugate comprising an anti-CD20 MAb or fragment thereof or an antibody fusion protein or fragment thereof of any one of claims 1-34 that binds to said cell, wherein said anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof is bound to at least one therapeutic agent, formulated in a pharmaceutically acceptable vehicle.

97. A method of claim 96, wherein said therapeutic agent comprises a cytotoxic agent, a radioactive label, an immunomodulator, a hormone, an enzyme, an oligonucleotide, a photoactive therapeutic agent or a combination thereof, formulated in a pharmaceutically acceptable vehicle.

98. A method of any one of claims 78, 81, 84, 87, 91, 94 or 97, wherein said cytotoxic agent is a drug or a toxin.

99. A method of claim 98, wherein said drug possesses the pharmaceutical property selected from the group consisting of antimitotic, alkylating, antibiotic, antimetabolite, antiangiogenic, apoptotic, antikinase and alkaloid agents, taxanes, and combinations thereof.

100. A method of claim 98, wherein said drug is selected from the group consisting of nitrogen mustards, ethylenimine derivatives, alkyl sulfonates, nitrosoureas, triazenes, folic acid analogs, COX-2 inhibitors, pyrimidine analogs, purine analogs, antibiotics, enzymes, epipodophyllotoxins, platinum coordination complexes, vinca alkaloids, substituted ureas, methyl hydrazine derivatives, adrenocortical suppressants, antagonists, endostatin, taxols, camptothecins, anthracyclines, and their analogs, and a combination thereof.

101. A method of claim 98, wherein said toxin selected from the group consisting of ricin, abrin, alpha toxin, saporin, ribonuclease (RNase), DNase I, *Staphylococcal* enterotoxin-A, pokeweed antiviral protein, gelonin, diphtherin toxin, *Pseudomonas* exotoxin, and *Pseudomonas* endotoxin.

102. A method of any one of claims 78, 81, 84, 87, 91, 94 or 97, wherein said immunomodulator is selected from the group consisting of a cytokine, a stem cell growth factor, a lymphotoxin, a hematopoietic factor, a colony stimulating factor (CSF), an interferon (IFN), a stem cell growth factor, erythropoietin, thrombopoietin and a combination thereof.

103. A method of claim 102, wherein said lymphotoxin is tumor necrosis factor (TNF), said hematopoietic factor is an interleukin (IL), said colony stimulating factor is granulocyte-colony stimulating factor (G-CSF) or granulocyte macrophage-colony stimulating factor (GM-CSF)), said interferon is interferons-α, -β or -γ, and said stem cell growth factor is designated "S1 factor".

104. A method of claim 102, wherein said immunomodulator comprises IL-1, IL-2, IL-3, IL-6, IL-10, IL-12, IL-18, IL-21, interferon-γ, TNF-α or a combination thereof.

105. A method of any one of claims 78, 81, 84, 87, 91, 94 or 97, wherein said radioactive label has an energy between 60 and 4,000 keV.

106. A method of claim 105, wherein said radioactive label is selected from the group consisting of ^{225}Ac, , ^{67}Ga, ^{90}Y, ^{111}In, ^{131}I, ^{125}I, ^{186}Re, ^{188}Re, ^{177}Lu, ^{64}Cu, ^{67}Cu, ^{212}Bi, ^{213}Bi, ^{211}At, ^{32}P, and combinations thereof.

107. A method of any one of claims 80, 83, 86, 89, 93, 96 or 98, wherein said photoactive therapeutic agent is a chromogen or dye.

108. A method of any one of claims 75-107, wherein said subject is a mammal.

109. A method of claim 108, wherein said mammal is a human, dog or cat.

110. A method of diagnosing a B-cell lymphoma or leukemia or an autoimmune disease in a subject comprising administering to said subject a diagnostic conjugate comprising an anti-CD20 MAb or fragment thereof or an antibody fusion protein or fragment thereof of any one of claims 1-34 that binds to said cell, wherein said anti-CD20 MAb or fragment thereof or antibody fusion protein or fragment thereof is bound to at least one diagnostic agent, formulated in a pharmaceutically acceptable vehicle.

111. A method of claim 110, wherein said diagnostic agent comprises at least one of a radioactive label, a photoactive diagnostic agent or a non-radioactive label.

112. A method of claim 111, wherein said radioactive label is selected from the group consisting of a gamma-, beta-, or positron-emitting isotope.

113. A method of claim 112, wherein said radioactive label has an energy between 60 and 700 keV.

114. A method of claim 112, wherein said radioactive label is selected from the group consisting of ^{125}I, ^{131}I, ^{123}I, ^{86}Y, ^{186}Re, ^{188}Re, ^{62}Cu, ^{64}Cu, ^{67}Cu, ^{111}In, ^{67}Ga, ^{68}Ga, ^{99m}Tc, ^{94m}Tc, ^{18}F, ^{11}C, ^{13}N, ^{15}O, and ^{76}Br.

115. A method of claim 111, wherein said non-radioactive label is a contrast agent or a non-radioactive metal.

116. A method of claim 115, wherein said radioactive label is a paramagnetic ion.

117. A method of claim 111, wherein said non-radioactive label is gadolinium, manganese or iron.

118. A method for pretargeting a cell in a patients suffering from a B-cell lymphoma or leukemia or an autoimmune disease comprising:

(i) administering an antibody fusion protein or fragment thereof of any one of claims 31-33 having at least one arm that specifically binds said cell and at least one other arm that specifically binds a targetable conjugate;

(ii) optionally, administering to said patient a clearing composition, and allowing said composition to clear non-antigen bound antibody fusion protein or antibody fragments thereof from circulation; and

(iii) administering to said patient a targetable conjugate comprising a carrier portion which comprises or bears at least one epitope recognizable by said at least one other arm of said antibody fusion protein or fragment thereof, and is conjugated at least one first therapeutic or diagnostic agent.

119. The method of claim 118, wherein said antibody fusion protein or fragment thereof is a bispecific antibody or fragment thereof.

120. The method of claim 119, wherein said bispecific antibody is a diabody.

121. The method of any of claims 118-120, wherein said first therapeutic agent is selected from the group consisting of a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, a cytotoxic agent, an oligonucleotide and a combination thereof and wherein said first diagnostic agent is at least one of a radioactive label, a photoactive diagnostic agent or a non-radioactive label.

122. The method of claim 118-121, wherein said antibody fusion protein or fragment thereof is conjugated to a second therapeutic or diagnostic agent.

123. The method of claim 122, wherein said second therapeutic agent is selected from the group consisting of a radioactive label, an immunomodulator, a hormone, a photoactive therapeutic agent, a cytotoxic agent, an oligonucleotide and a combination thereof and wherein said second diagnostic agent is at least one of a radioactive label, a photoactive diagnostic agent or a non-radioactive label.

124. The method of claim 122 or 123, wherein said first and second therapeutic agent or diagnostic agent are the same.

A20Vk

```
GACATTCAGCTGACCCAGTCTCCAGCAATCCTGTCTGCATCTCCAGGGGAGAAGGTCACAATGACTTGCAGGGCCAGCTCAAGTGTAAGT
---------+---------+---------+---------+---------+---------+---------+---------+---------+ 90
CTGTAAGTCGACTGGGTCAGAGGTCGTTAGGACAGACGTAGAGGTCCCCTCTTCCAGTGTTACTGAACGTCCCGGTCGAGTTCACATTCA
 1                  10                  20                 27 29 30
 D  I  Q  L  T  Q  S  P  A  I  L  S  A  S  P  G  E  K  V  T  M  T  C  R  A  S  S  S  V  S   30
                                                                     CDR1

TACATCCACTGGTTCCAGCAGAAGCCAGGATCCTCCCCCAAACCCTGGATTTATGCCACATCCAACCTGGCTTCTGGAGTCCCTGTTCGC
---------+---------+---------+---------+---------+---------+---------+---------+---------+ 180
ATGTAGGTGACCAAGGTCGTCTTCGGTCCTAGGAGGGGGTTTGGGACCTAAATACGGTGTAGGTTGGACCGAAGACCTCAGGGACAAGCG
                              40                  50                  60
 Y  I  H  W  F  Q  Q  K  P  G  S  S  P  K  P  W  I  Y  A  T  S  N  L  A  S  G  V  P  V  R   60
                                                          CDR2

TTCAGTGGCAGTGGGTCTGGGACTTCTTACTCTCTCACAATCAGCAGAGTGGAGGCTGAAGATGCTGCCACTTATTACTGCCAGCAGTGG
---------+---------+---------+---------+---------+---------+---------+---------+---------+ 270
AAGTCACCGTCACCCAGACCCTGAAGAATGAGAGAGTGTTAGTCGTCTCACCTCCGACTTCTACGACGGTGAATAATGACGGTCGTCACC
                              70                  80                  90
 F  S  G  S  G  S  G  T  S  Y  S  L  T  I  S  R  V  E  A  E  D  A  A  T  Y  Y  C  Q  Q  W   90

ACTAGTAACCCACCCACGTTCGGAGGGGGGACCAAGCTGGAGATCTAAC
---------+---------+---------+---------+---------                                          359
TGATCATTGGGTGGGTGCAAGCCTCCCCCCTGGTTCGACCTCTAGATTG
                              100
 T  S  N  P  P  T  F  G  G  G  T  K  L  E  I                                                105
 CDR3
```

Figure 1A.

A20VH

```
GTACAACTGCAGCAGCCTGGGGCTGAGCTGGTGAAGCCTGGGGCCTCAGTGAAGATGTCCTGCAAGGCTTCTGGCTACACATTTACCAGT
---------+---------+---------+---------+---------+---------+---------+---------+---------+  90
CATGTTGACGTCGTCGGACCCCGACTCGACCACTTCGGACCCCGGAGTCACTTCTACAGGACGTTCCGAAGACCGATGTGTAAATGGTCA
 2                 10                  20                   30
 V  Q  L  Q  Q  P  G  A  E  L  V  K  P  G  A  S  V  K  M  S  C  K  A  S  G  Y  T  F  T  S

TACAATATGCACTGGGTAAAACAGACACCTGGTCGGGGCCTGGAATGGATTGGAGCTATTTATCCCGGAAATGGTGATACTTCCTACAAT
---------+---------+---------+---------+---------+---------+---------+---------+---------+ 180
ATGTTATACGTGACCCATTTTGTCTGTGGACCAGCCCCGGACCTTACCTAACCTCGATAAATAGGGCCTTTACCACTATGAAGGATGTTA
                       40                      50  52  A                 60
 Y  N  M  H  W  V  K  Q  T  P  G  R  G  L  E  W  I  G  A  I  Y  P  G  N  G  D  T  S  Y  N
 CDR1                                                               CDR 2

CAGAAGTTCAAAGGCAAGGCCACATTGACTGCAGACAAATCCTCCAGCACAGCCTACATGCAGCTCAGCAGCCTGACATCTGAGGACTCT
---------+---------+---------+---------+---------+---------+---------+---------+---------+ 270
GTCTTCAAGTTTCCGTTCCGGTGTAACTGACGTCTGTTTAGGAGGTCGTGTCGGATGTACGTCGAGTCGTCGGACTGTAGACTCCTGAGA
                         70                          80  82  A  B  C
 Q  K  F  K  G  K  A  T  L  T  A  D  K  S  S  S  T  A  Y  M  Q  L  S  S  L  T  S  E  D  S

GCGGTCTATTACTGTGCAAGATCGACTTACTACGGCGGTGACTGGTACTTCGATGTCTGGGGCCAAGGGACCACGGTCACCGTCTCCTCA
---------+---------+---------+---------+---------+---------+---------+---------+---------+ 360
CGCCAGATAATGACACGTTCTAGCTGAATGATGCCGCCACTGACCATGAAGCTACAGACCCCGGTTCCCTGGTGCCAGTGGCAGAGGAGT
     90                 100 A  B  C  D                          110
 A  V  Y  Y  C  A  R  S  T  Y  Y  G  G  D  W  Y  F  D  V  W  G  Q  G  T  T  V  T  V  S  S
                            CDR3
```

Figure 1B.

cA20Vk

```
GACATCCAGCTGACCCAGTCTCCAGCAATCCTGTCTGCATCTCCAGGGGAGAAGGTCACAATGACTTGCAGGGCCAGCTCAAGTGTAAGT    90
 1                    10                  20             27 29 30
 D  I  Q  L  T  Q  S  P  A  I  L  S  A  S  P  G  E  K  V  T  M  T  C  R  A  S  S  S  V  S
                                                                      CDR1

TACATCCACTGGTTCCAGCAGAAGCCAGGATCCTCCCCCAAACCCTGGATTTATGCCACATCCAACCTGGCTTCTGGAGTCCCTGTTCGC   180
                40                  50                  60
 Y  I  H  W  F  Q  Q  K  P  G  S  S  P  K  P  W  I  Y  A  T  S  N  L  A  S  G  V  P  V  R
                                                       CDR2

TTCAGTGGCAGTGGGTCTGGGACTTCTTACTCTCTCACAATCAGCAGAGTGGAGGCTGAAGATGCTGCCACTTATTACTGCCAGCAGTGG   270
                70                  80                  90
 F  S  G  S  G  S  G  T  S  Y  S  L  T  I  S  R  V  E  A  E  D  A  A  T  Y  Y  C  Q  Q  W

ACTAGTAACCCACCCACGTTCGGAGGGGGGACCAAGCTGGAGATCAAA                                            318
                 100              107
 T  S  N  P  P  T  F  G  G  G  T  K  L  E  I  K
 CDR3
```

Figure 2A.

cA20VH

CAGGTCCAACTGCAGCAGCCTGGGGCTGAGCTGGTGAAGCCTGGGGCCTCAGTGAAGATGTCCTGCAAGGCTTCTGGCTACACATTTACC 90
1 10 20 30
Q V Q L Q Q P G A E L V K P G A S V K M S C K A S G Y T F T

AGTTACAATATGCACTGGGTAAAACAGACACCTGGTCGGGGCCTGGAATGGATTGGAGCTATTTATCCCGGAAATGGTGATACTTCCTAC 180
40 50 52 A
S Y N M H W V K Q T P G R G L E W I G **A I Y P G N G D T S Y**
CDR1 CDR 2

AATCAGAAGTTCAAAGGCAAGGCCACATTGACTGCAGACAAATCCTCCAGCACAGCCTACATGCAGCTCAGCAGCCTGACATCTGAGGAC 270
60 70 80 82 A B C
N Q K F K G K A T L T A D K S S S T A Y M Q L S S L T S E D

TCTGCGGTCTATTACTGTGCAAGATCGACTTACTACGGCGGTGACTGGTACTTCGATGTCTGGGGCCAAGGGACCACGGTCACCGTCTCC 360
90 100 A B C D 110
S A V Y Y C A R **S T Y Y G G D W Y F D V** W G Q G T T V T V S
CDR3

TCA 363
113
S

Figure 2B.

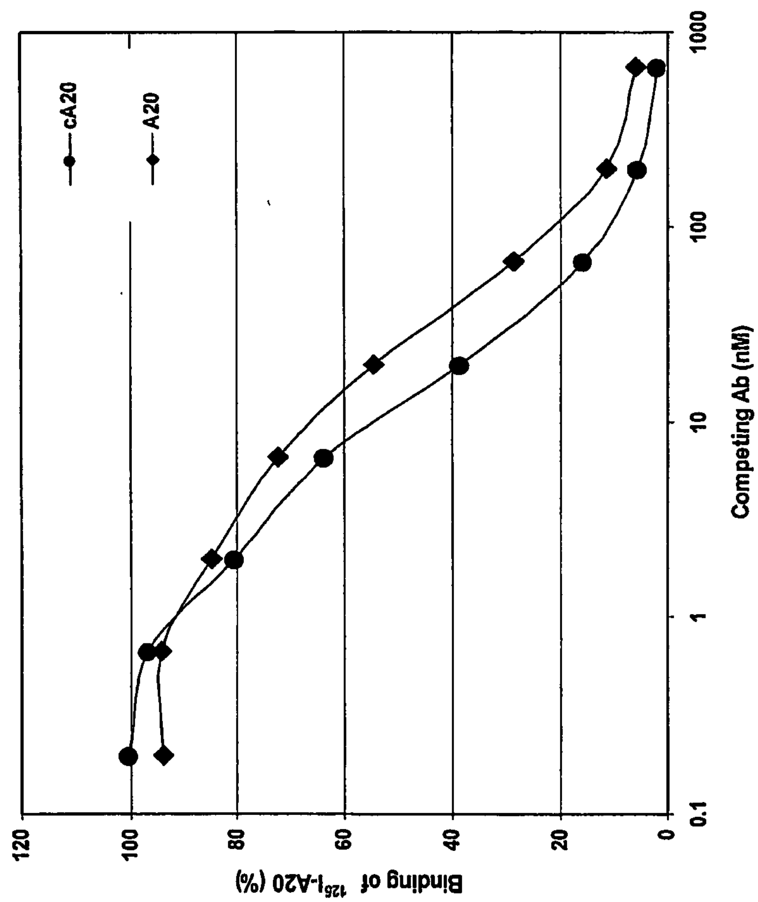
cA20
A20
Binding of 125I-A20 (%)
Competing Ab (nM)
120
100
80
60
40
20
0
0.1
1
10
100
1000

Figure 3

```
          1        10        20        30        40
EU_VH     PVQLVQSGAEVKKPGSSVKVSCKASGGTFSRSAIIWVRQA
cA20VH    Q···Q·P···LV···A···M······Y··TSYNMH··K·T
hA20VH1   Q···Q·····················Y··TSYNMH··K··
hA20VH2   Q···Q·····················Y···SYNMH·····

                   50 52 A    60        70
EU_VH     PGQGLEWMGGIVPMFGPPNYAQKFQGRVTITADESTNTAY
cA20VH    ··R····I·A·Y·GN·DTS·N···K·KA·L···K·SS···
hA20VH1   ·······I·A·Y·GN·DTS·N···K·KA·L··········
hA20VH2   ·········A·Y·GN·DTS·N···K··A············

          80 82 A B C       90      100 A B C D
EU_VH     MELSSLRSEDTAFYFCAGGYGIYS----PEEYNGGLVTVS
cA20VH    ·Q····T···S·V·Y··RSTYYGGDWYFDV
hA20VH1   ···············Y··RSTYYGGDWYFDV
hA20VH2   ·················RSTYYGGDWYFDV

          103      110  113
NEWM_VH   WGQGSLVTVSS
cA20VH    ····TT·····
hA20VH1   ····TT·····
hA20VH2   ····TT·····
```

Figure 4A.

```
         1        10        20        30        40
REIVk    DIQMTQSPSSLSASVGDRVTITCQASQDIIKYLNWYQQTP
cA20Vk   ···L····AI····P·EK··M··R··S-SVS·IH·F··K·
hA20Vk   ···L················M··R··S-SVS·IH·F··K·

                  50        60        70        80
REIVk    GKAPKLLIYEASNLQAGVPSRFSGSGSGTDYTFTISSLQP
cA20Vk   ·SS··PW··AT···AS···V·········S·SL···RVEA
hA20Vk   ·····PW··AT···AS···V····················

                  90        100    107
REIVk    EDIATYYCQQYQSLPYTFGQGTKLQIT
cA20Vk   ··A·······WT·N·P···G····E·K
hA20Vk   ··········WT·N·P···G····E·K
```

Figure 4B.

```
XbaI
tctagacacaggacctcaccATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACAGCTACaggta -91
                    M  G  W  S  C  I  I  L  F  L  V  A  T  A  T        -5

AggggctcacagtagcaggcttgaggtctggacatatatatgggtgacaatgacatccactttgcctttctctccacAGGTGTCCACTCC -1
                                                                              G  V  H  S   -1

PvuII
GACATCCAGCTGACCCAGTCTCCATCATCTCTGAGCGCATCTGTTGGAGATAGGGTCACTATGACTTGTAGGGCCAGCTCAAGTGTAAGT 90
 D  I  Q  L  T  Q  S  P  S  S  L  S  A  S  V  G  D  R  V  T  M  T  C  R  A  S  S  S  V  S  30
                                                                       CDR1

TACATCCACTGGTTCCAGCAGAAACCAGGGAAAGCACCTAAACCCTGGATTTATGCCACTTCGAACCTGGCTTCTGGTGTCCCTGTCCGA 180
 Y  I  H  W  F  Q  Q  K  P  G  K  A  P  K  P  W  I  Y  A  T  S  N  L  A  S  G  V  P  V  R  61
                                                       CDR2

TTCTCTGGCAGCGGATCTGGGACAGATTACACTTTCACCATCAGCTCTCTTCAACCAGAAGACATTGCAACATATTATTGTCAGCAGTGG 270
 F  S  G  S  G  S  G  T  D  Y  T  F  T  I  S  S  L  Q  P  E  D  I  A  T  Y  Y  C  Q  Q  W  91

                                    BglII/BclI                                   BamHI
ACTAGTAACCCACCCACGTTCGGTGGAGGGACCAAGCTGGAGATCAAACgtgagtagaatttaaactttgcttcctcagttggatcc 357
 T  S  N  P  P  T  F  G  G  G  T  K  L  E  I  K                                        107
 CDR3
```

Figure 5A.

```
 XhoI
 ctcgagcacacaggacctcaccATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACAGCTACaggta  -91
                       M  G  W  S  C  I  I  L  F  L  V  A  T  A  T         -5

AggggctcacagtagcaggcttgaggtctggacatatatatgggtgacaatgacatccactttgcctttctctccacAGGTGTCCACTCC  -1
                                                                              G  V  H  S      -1

         PstI
CAGGTCCAACTGCAGCAATCAGGGGCTGAAGTCAAGAAACCTGGGTCATCGGTGAAGGTCTCCTGCAAGGCTTCTGGCTACACCTTTACT  90
 Q  V  Q  L  Q  Q  S  G  A  E  V  K  K  P  G  S  S  V  K  V  S  C  K  A  S  G  Y  T  F  T   30

AGTTACAATATGCACTGGGTCAAGCAGGCACCTGGACAGGGTCTGGAATGGATTGGAGCTATTTATCCCGGAAATGGTGATACTTCCTAC  180
 S  Y  N  M  H  W  V  K  Q  A  P  G  Q  G  L  E  W  I  G  A  I  Y  P  G  N  G  D  T  S  Y   59
    CDR1                                                                           CDR2

AATCAGAAGTTCAAGGGTAAAGCCACACTGACTGCCGACGAATCCACCAATACAGCCTACATGGAGCTGAGCAGCCTGAGGTCTGAGGAC  270
 N  Q  K  F  K  G  K  A  T  L  T  A  D  E  S  T  N  T  A  Y  M  E  L  S  S  L  R  S  E  D   86

                                                                                BstEII
ACGGCATTTTATTACTGTGCAAGATCGACTTACTACGGCGGTGACTGGTACTTCGATGTCTGGGGCCAAGGCACCACGGTCACCGTCTCC  360
 T  A  F  Y  Y  C  A  R  S  T  Y  Y  G  G  D  W  Y  F  D  V  W  G  Q  G  T  T  V  T  V  S   112
                                      CDR3

TCAGgtgagtccttacaacctctctcttctattcagcttaaatagatttactgcatttgttgggggggaaatgtgtgtatctgaatttc  450
 S                                                                                            113

Aggtcatgaaggactagggacaccttgggagtcagaaagggtcattgggagcccgggctgatgcagacagacatcctcagctcccagact  540

               BamHI
tcatggccagagatttataggatcc                                                                    565
```

Figure 5B.

```
XhoI
ctcgagcacacaggacctcaccATGGGATGGAGCTGTATCATCCTCTTCTTGGTAGCAACAGCTACaggta  -91
                      M  G  W  S  C  I  I  L  F  L  V  A  T  A  T       -5

AggggctcacagtagcaggcttgaggtctggacatatatatgggtgacaatgacatccactttgcctttctctccacAGGTGTCCACTCC  -1
                                                                             G  V  H  S     -1

CAGGTCCAACTGCAGCAATCAGGGGCTGAAGTCAAGAAACCTGGGTCATCAGTGAAGGTCTCCTGCAAGGCTTCTGGCTACACCTTTAGT  90
 Q  V  Q  L  Q  Q  S  G  A  E  V  K  K  P  G  S  S  V  K  V  S  C  K  A  S  G  Y  T  F  S   30

AGTTACAATATGCACTGGGTCAGACAGGCACCTGGACAGGGTCTGGAATGGATGGGAGCTATTTATCCCGGAAATGGTGATACTTCCTAC  180
 S  Y  N  M  H  W  V  R  Q  A  P  G  Q  G  L  E  W  M  G  A  I  Y  P  G  N  G  D  T  S  Y   59
   CDR1                                                                          CDR2

AATCAGAAGTTCAAGGGTAGAGCCACAATAACTGCCGACGAATCCACCAATACAGCCTACATGGAGCTGAGCAGCCTGAGGTCTGAGGAC  270
 N  Q  K  F  K  G  R  A  T  I  T  A  D  E  S  T  N  T  A  Y  M  E  L  S  S  L  R  S  E  D   86

ACGGCATTTTATTTTTGTGCAAGATCGACTTACTACGGCGGTGACTGGTACTTCGATGTCTGGGGCCAAGGCACCACGGTCACCGTCTCC  360
 T  A  F  Y  F  C  A  R  S  T  Y  Y  G  G  D  W  Y  F  D  V  W  G  Q  G  T  T  V  T  V  S   112
                                       CDR3

TCAGgtgagtccttacaacctctctcttctattcagcttaaatagattttactgcatttgttggggggaaatgtgtgtatctgaatttc  450
 S                                                                                          113

Aggtcatgaaggactagggacaccttgggagtcagaaagggtcattgggagcccgggctgatgcagacagacatcctcagctcccagact  540

             BamHI
Tcatggccagagatttataggatcc                                                                   565
```

Figure 5C.

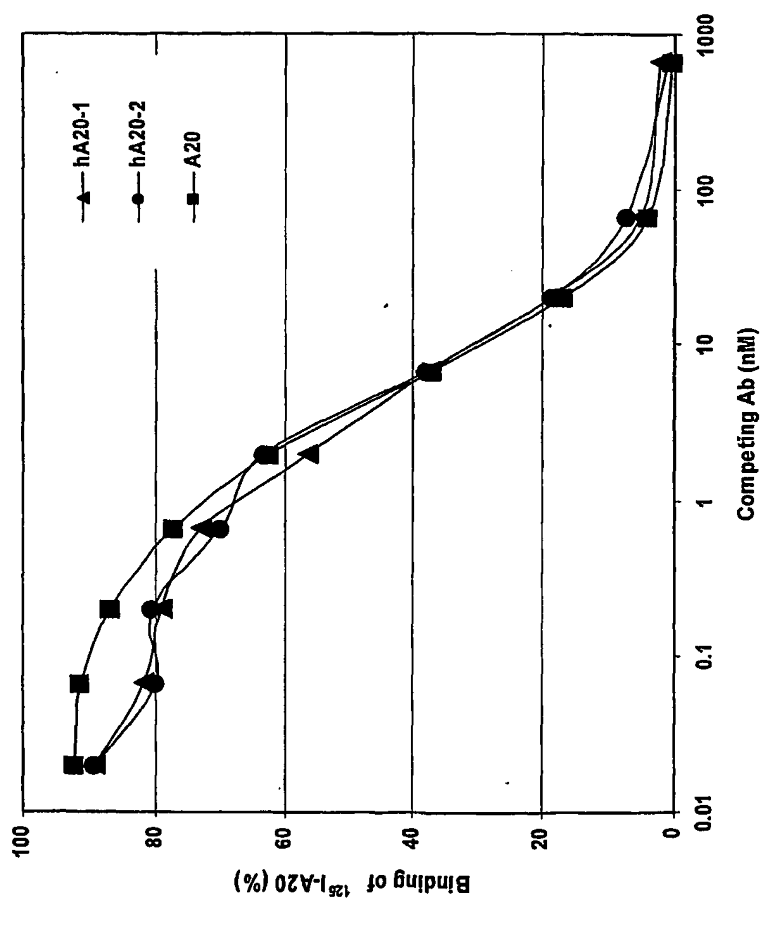
hA20-1
hA20-2
A20
Binding of 125I-A20 (%)
Competing Ab (nM)
100
80
60
40
20
0
0.01
0.1
1
10
100
1000

Figure 6A.

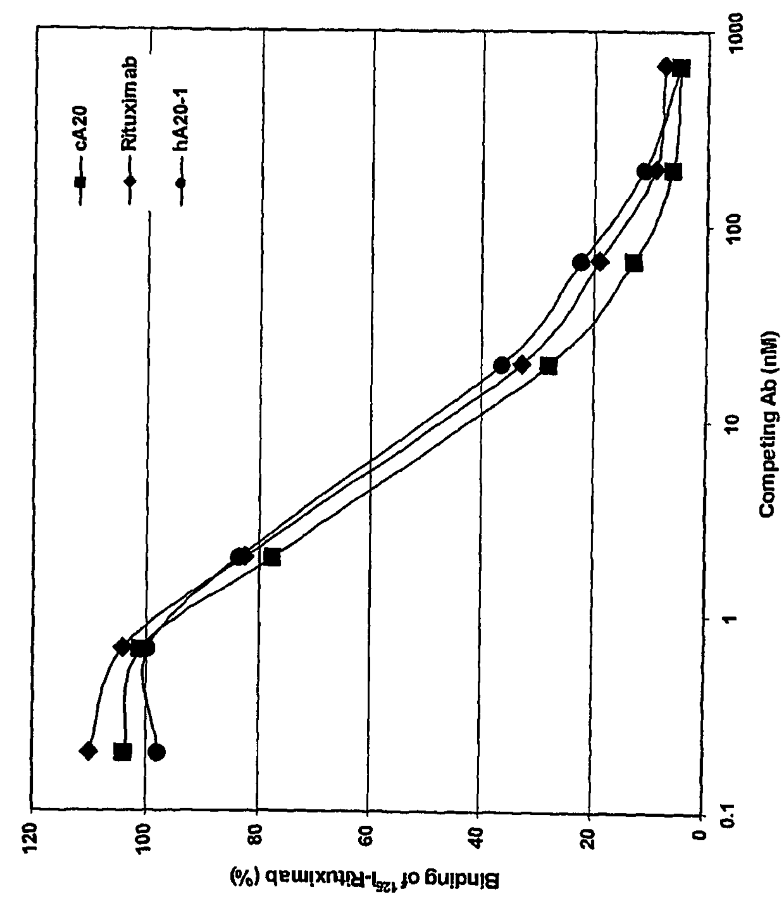
cA20
Rituximab
hA20-1
Binding of 125I-Rituximab (%)
120
100
80
60
40
20
0
0.1
1
10
100
1000
Competing Ab (nM)

Figure 6B.

```
     GCCTCCACCAAGGGCCCATCGGTCTTCCCCCTGGCACCCTCCTCCAAGAGCACCTCTGGGGGCACAGCGGCCCTGGGCTGCCTGGTCAAGGACTACTTCCCCGAACCGGTGACGGTGTCG  120
118  A S T K G P S V F P L A P S S K S T S G G T A A L G C L V K D Y F P E P V T V S
     TGGAACTCAGGCGCCCTGACCAGCGGCGTGCACACCTTCCCGGCTGTCCTACAGTCCTCAGGACTCTACTCCCTCAGCAGCGTGGTGACCGTGCCCTCCAGCAGCTTGGGCACCCAGACC  240
158  W N S G A L T S G V H T F P A V L Q S S G L Y S L S S V V T V P S S S L G T Q T
     TACATCTGCAACGTGAATCACAAGCCCAGCAACACCAAGGTGGACAAGAGAGTTGAGCCCAAATCTTGTGACAAAACTCACACATGCCCACCGTGCCCAGCACCTGAACTCCTGGGGGGA  360
198  Y I C N V N H K P S N T K V D K R V E P K S C D K T H T C P P C P A P E L L G G
     CCGTCAGTCTTCCTCTTCCCCCCAAAACCCAAGGACACCCTCATGATCTCCCGGACCCCTGAGGTCACATGCGTGGTGGTGGACGTGAGCCACGAAGACCCTGAGGTCAAGTTCAACTGG  480
238  P S V F L F P P K P K D T L M I S R T P E V T C V V V D V S H E D P E V K F N W
     TACGTGGACGGCGTGGAGGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGCAGTACAACAGCACGTACCGTGTGGTCAGCGTCCTCACCGTCCTGCACCAGGACTGGCTGAATGGCAAG  600
278  Y V D G V E V H N A K T K P R E E Q Y N S T Y R V V S V L T V L H Q D W L N G K
     GAGTACAAGTGCAAGGTCTCCAACAAAGCCCTCCCAGCCCCCATCGAGAAAACCATCTCCAAAGCCAAAGGGCAGCCCCGAGAACCACAGGTGTACACCCTGCCCCCATCCCGGGAGGAG  720
318  E Y K C K V S N K A L P A P I E K T I S K A K G Q P R E P Q V Y T L P P S R E E
     ATGACCAAGAACCAGGTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCCAGCGACATCGCCGTGGAGTGGGAGAGCAATGGGCAGCCGGAGAACAACTACAAGACCACGCCTCCCGTG  840
358  M T K N Q V S L T C L V K G F Y P S D I A V E W E S N G Q P E N N Y K T T P P V
     CTGGACTCCGACGGCTCCTTCTTCCTCTATAGCAAGCTCACCGTGGACAAGAGCAGGTGGCAGCAGGGGAACGTCTTCTCATGCTCCGTGATGCATGAGGCTCTGCACAACCACTACACG  960
398  L D S D G S F F L Y S K L T V D K S R W Q Q G N V F S C S V M H E A L H N H Y T
     CAGAAGAGCCTCTCCCTGTCTCCGGGTAAATGA  993
438  Q K S L S L S P G K *
```

Fig. 7A. The CH sequence of hIgG1.

```
    CGAACTGTGGCTGCACCATCTGTCTTCATCTTCCCGCCATCTGATGAGCAGTTGAAATCTGGAACTGCCTCTGTTGTGTGCCTGCTGAATAACTTCTATCCCAGAGAGGCCAAAGTACAG 120
108  R  T  V  A  A  P  S  V  F  I  F  P  P  S  D  E  Q  L  K  S  G  T  A  S  V  V  C  L  L  N  N  F  Y  P  R  E  A  K  V  Q

    TGGAAGGTGGATAACGCCCTCCAATCGGGTAACTCCCAGGAGAGTGTCACAGAGCAGGACAGCAAGGACAGCACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAAAGCAGACTACGAG 240
148  W  K  V  D  N  A  L  Q  S  G  N  S  Q  E  S  V  T  E  Q  D  S  K  D  S  T  Y  S  L  S  S  T  L  T  L  S  K  A  D  Y  E

    AAACACAAAGTCTACGCCTGCGAAGTCACCCATCAGGGCCTGAGCTCGCCCGTCACAAAGAGCTTCAACAGGGGAGAGTGTTGA 324
188  K  H  K  V  Y  A  C  E  V  T  H  Q  G  L  S  S  P  V  T  K  S  F  N  R  G  E  C  *
```

Fig. 7B. The constant region sequence of human kappa chain.

Cell surface competitive binding of CD20 MAbs vs. m2B8 or rituximab (C2B8)

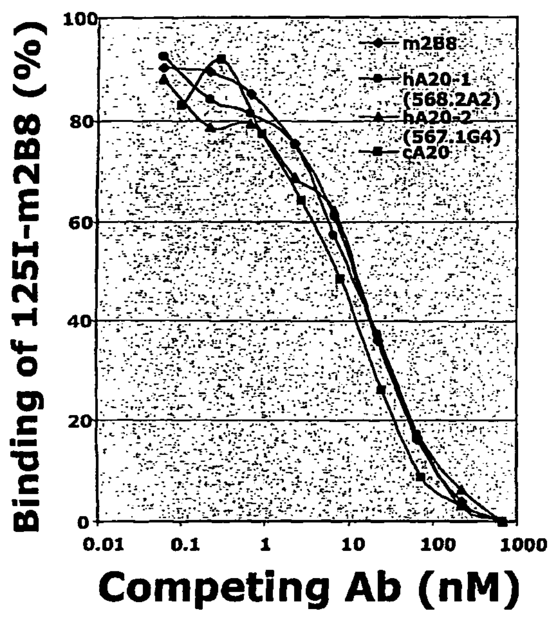

Figure 8A

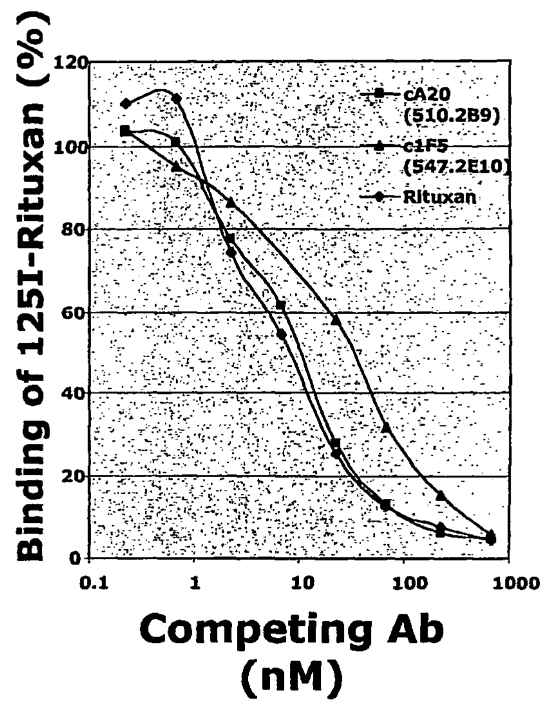

Figure 8B

Figure 8

Competitive Binding to ^{125}I Rituxan

(B1, like 1F5, has lower affinity than hA20-1 or rituximab [C2B8])

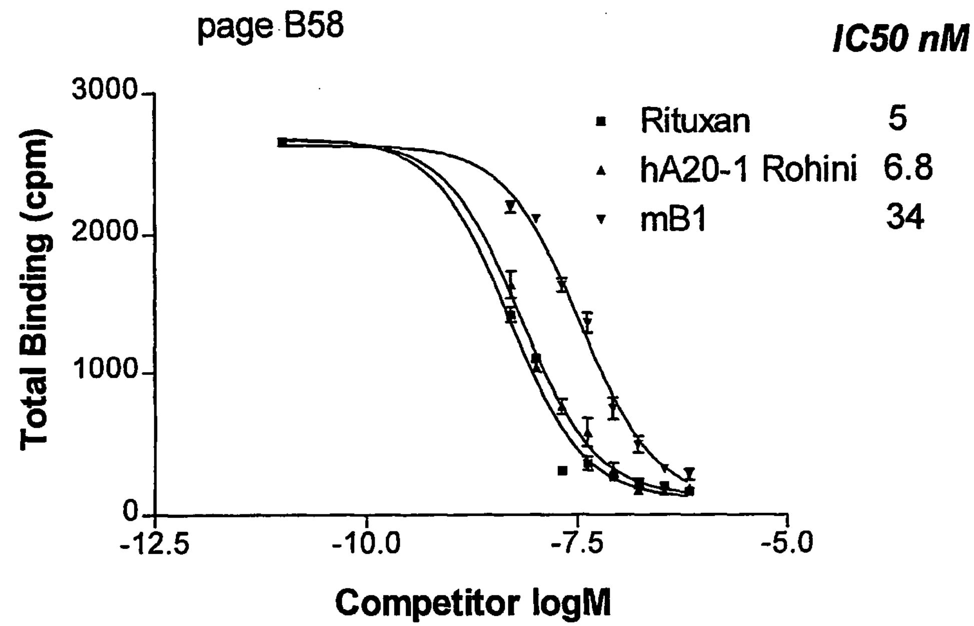

Figure 9

Cytotoxicity of crosslinked CD20 MAbs on Raji cells

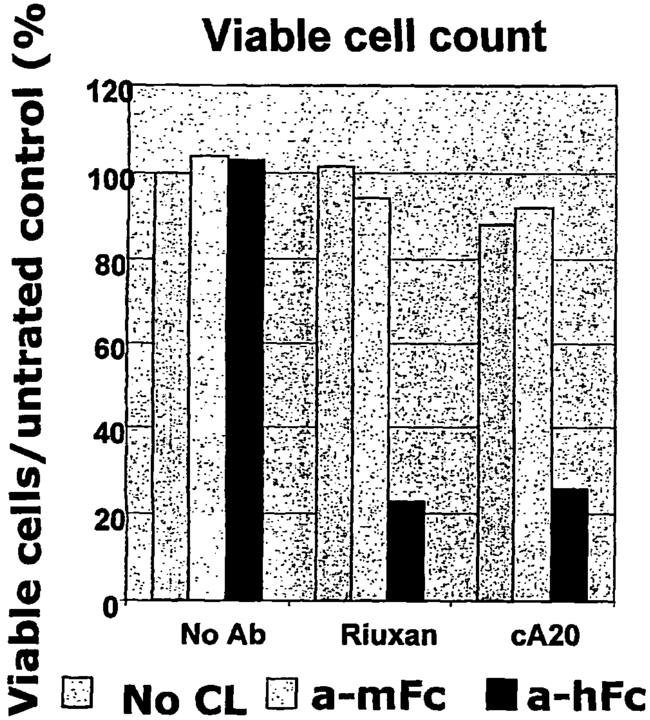

Figure 10A

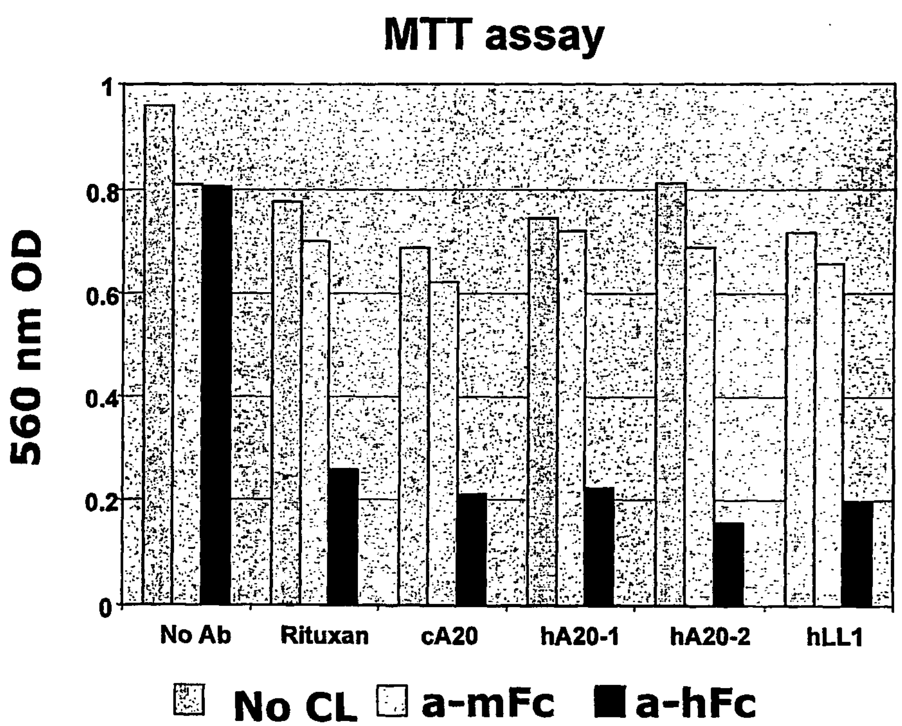

Figure 10B

Figure 10

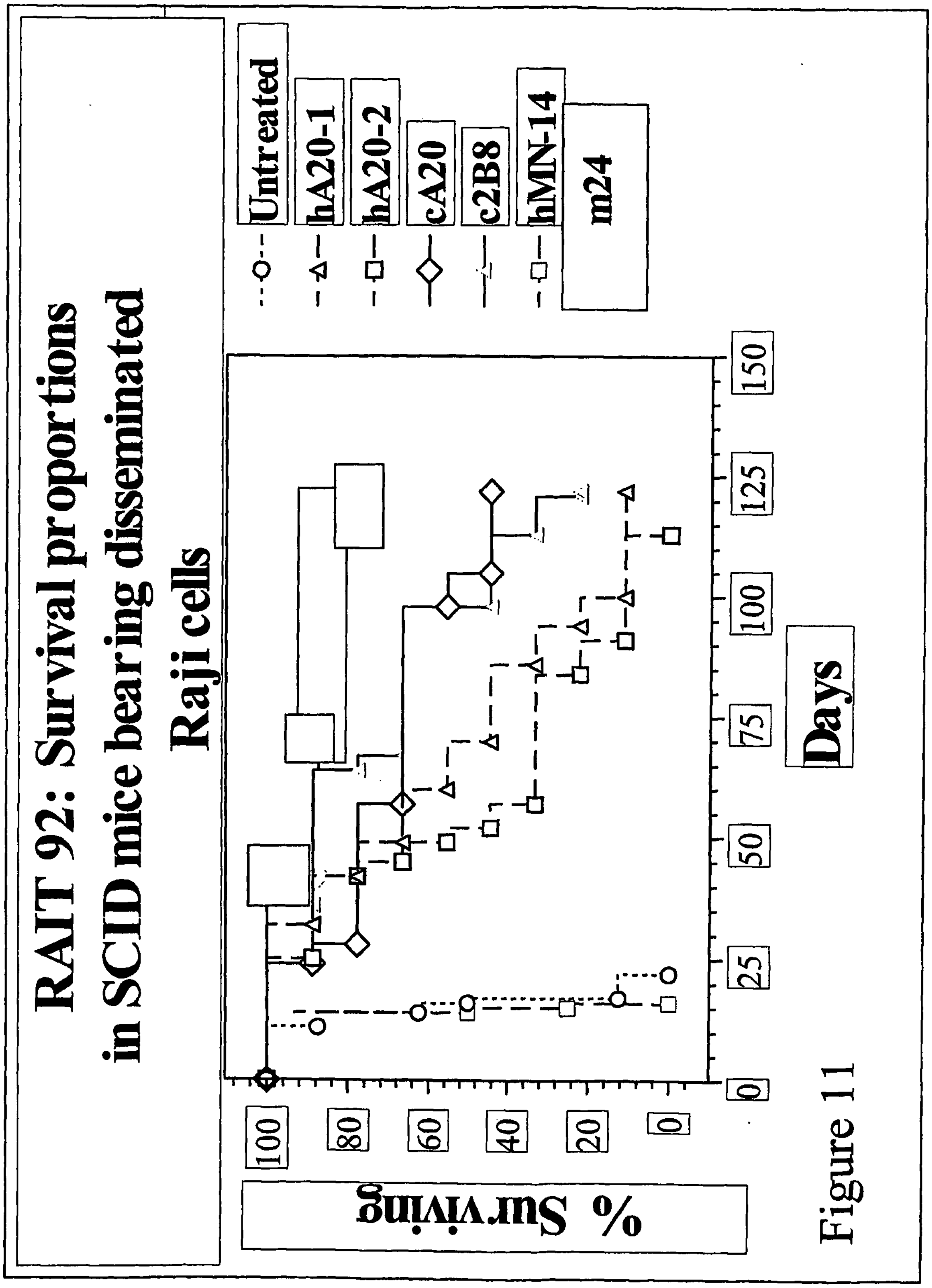
RAIT 92: Survival proportions in SCID mice bearing disseminated Raji cells
Untreated
hA20-1
hA20-2
cA20
c2B8
hMN-14
m24
% Surviving
100
80
60
40
20
0
0
25
50
75
100
125
150
Days

Figure 11

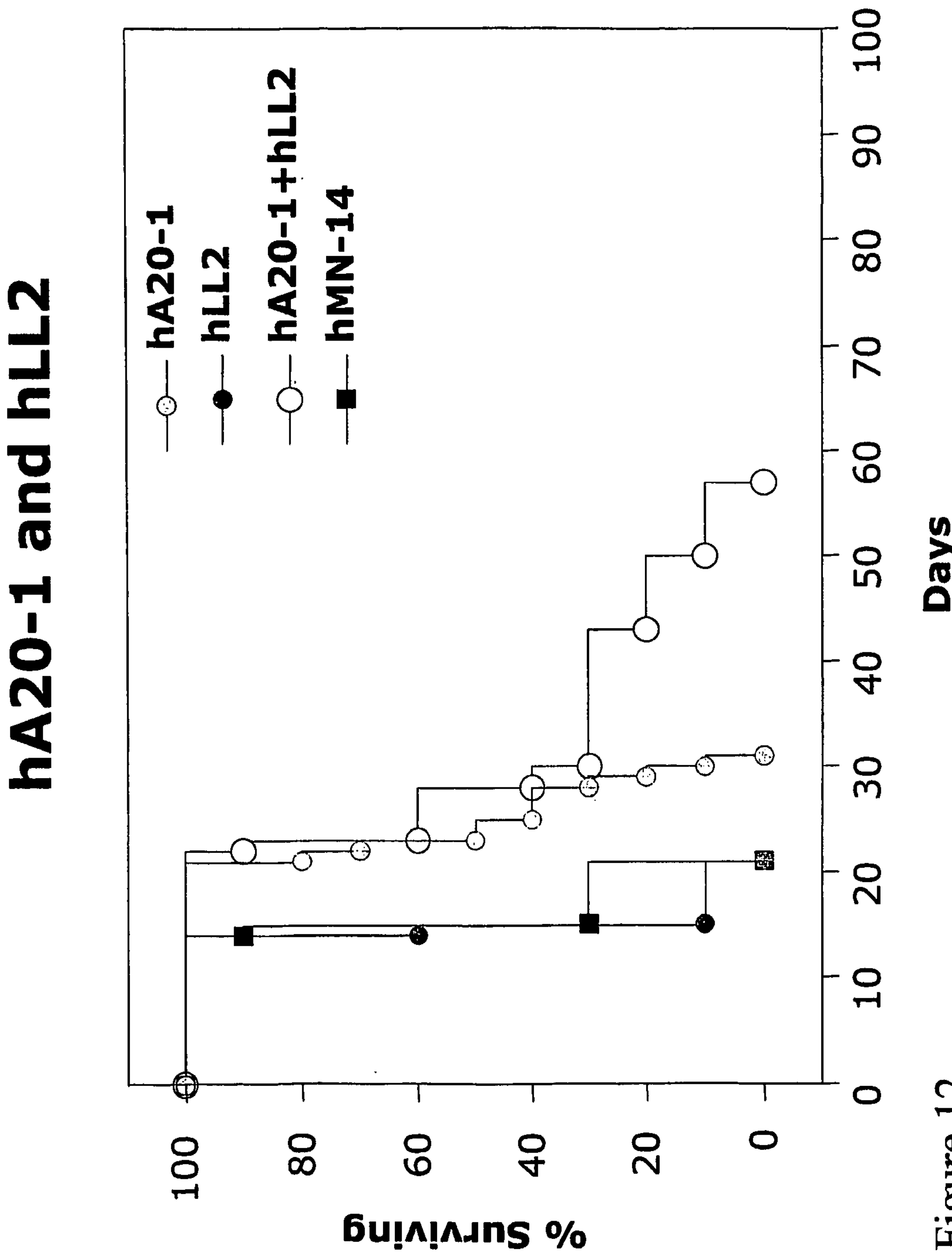
hA20-1 and hLL2
hA20-1
hLL2
hA20-1+hLL2
hMN-14
% Surviving
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Days

Figure 12